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GEORGE REID
Editor

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REFINER
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OLUME 13, No. 6 JUNE, 1934

In Doubt Efforts to place the petroleum industry under federal control by specific legislation ran into a doubtful status as senators and congressmen drove toward an adjournment of Congress. The Thomas-Disney bill has the approval of the President but it did not become a part of the lash he waved early in June when he urged the legislators to get certain things done before rushing home to begin their campaigns for re-election.

Control of the petroleum industry is one of the items the administration would like to accomplish but it does not rank with some other desired legislation. Harold L. Ickes, administrator of the code, has been the chief administration spokesman in favor of the oil control bill. Men in executive position of importance in the industry have been fully as determined to bring the bill into a statute. Opposition has come from independent producers and from state officials, especially members of the Texas Railroad Commission.

Reversed A decision from the Fifth Court of Civil Appeals at New Orleans caused many to withdraw support from the Thomas-Disney bill. The effect of this decision was to reverse the decree of the trial court for the eastern district of Texas, wherein an injunction was granted Panama Refining Company et al to prevent agents of the code administrator from interfering with the operation of producing properties in the East Texas field. This decision put an end to federal regulation under the code in that field.

But the higher court found the National Industrial Recovery Act not contrary to the constitution on the points raised and further held that the petroleum code justified the presence of agents of the administrator on properties to insure operation of the rules.

With this decision enforcement agents went back to their duties along with an announcement from Washington that prosecutions would follow.

Prices Gasoline prices in Texas and Oklahoma stood a half cent higher at the beginning of June, as compared with the first part of May. The New Orleans decision, plus the refinery control plan under which major concerns are to buy surplus gasoline from independent plants brought this upswing.

Purchases by the big companies were largely responsible for sharp gains in East Texas refinery prices the first week in June. The prices set records for the year, and were among the highest in the history of the big refining district. Third-grade gasoline, chief product of the area, had risen by the middle of last week to an average price of around 4⅛ cents a gallon. Through continuous improvement the price had risen one-half cent within a week. Middle and first grades meanwhile rose a quarter cent each, going to 4½ and 4¾ cents, respectively.

In the region centering around Oklahoma and Kansas, in the meantime, the three grades rose one-eighth cent each, the new Group Three prices being 4¼, 4¾ and 5 cents.

Because of the strength of the refinery prices, termination of retail price wars in North and South Texas metropolitan areas was expected momentarily. For several weeks the wars, concentrated mostly on third-grade, with majors meeting independents' prices, had kept prices depressed in those areas, with the bottom grade retailing at 11 cents a gallon, including 5 cents for taxes.

Although independents inaugurated the low

prices, dropping from 16 to 14 to 12 to 11 cents, there were some among them last week who were charging that the majors were purposely prolonging the war, despite heavy losses, in order to inflate their gallonage to be used as bases in fixing quotas under the new refinery control section of the oil code, while at the same time holding independents down to low gallonage.

Profit At Last Since oil companies were able for the most part to realize substantial profit on their operations in the first quarter of 1934, it is to be anticipated that they will show even higher earnings for the second quarter. For the first quarter is ordinarily a relatively lean one for the oil concerns, with heavier volume of business coming in the second and third quarters, when gasoline consumption reaches peak levels. And this year the second quarter's results will be influenced not only by the seasonal increase in consumption, but also by the previously mentioned favorable factors, including rising prices, increase of demand not altogether seasonal, and generally satisfactory conditions.

First quarter financial results were better in general this year than they had been since 1930, with a high proportion of companies reporting substantial net profit, in contrast with large net loss in the 1933 first quarter. Contributing to the successful results were relatively favorable prices and a relatively large volume of business. Domestic demand for all oils was at an all-time first quarter peak, and total demand for all oils, including export demand, was at a first quarter level exceeded only in 1930.

More Oil June 1 the allowed production for the United States was raised to 2,528,300 barrels daily by the code administrator. This jump of 162,100 barrels daily was ordered because of increases in seasonal demand.

The increase came along in spite of statistics to indicate that oil producers have been bringing more oil to the surface than the code figures specify since allocations were inaugurated under its provisions.

Statistics Confidence that the oil industry's stability will not be upset, regardless of outcome of the Thomas-Disney bill, is strengthened by analysis of statistics covering recent months, including May. The figures tend to bear out contentions of opponents of the new legislation that crude production has not been actually excessive, despite output above the federal government allowables. They tend to show that instead of over-production, there has been under-estimating of demand for oils; that the allowables have been violated because they have not been high enough to conform with increasing demand.

It was recognition of this circumstance which prompted the large increase in the nation's allowable crude production effective June 1. The allowable was raised to 2,528,300 barrels daily from the 2,366,200 barrels per day authorized by the oil code administration for April and May.

Stocks While crude oil production has been above the federal government allowables during all but one of the nine months since advent of national regulation, crude stocks have declined in nearly all the months, coming down by a net amount of about 5,000,000 barrels.

During April and May the crude production allowables continued to be exceeded. In fact, the May excess was exceptionally large, amounting to about 130,000 barrels daily, exclusive of possibly 50,000 barrels of "hot" oil per day in East Texas. Yet at the end of May the nation's crude stocks are indicated to have been around or possibly under the amount on hand at the beginning of April.

During the two months the demand for crude was, moreover, artificially held down to some extent; as market requirements for gasoline and other petroleum products were supplied in part by withdrawals from stocks of those products held in storage. The stocks of finished gasoline were reduced 1,000,000 barrels in April and 1,500,000 barrels more in May.

Indicating that there has not been lately any actual overproduction of crude, the above facts tend at the same time also to discount greatly any cries to the effect that stricter control is needed to avert collapse of the industry's stability.

The New Means for Controlling Vapor Pressure

F. L. KALLAM

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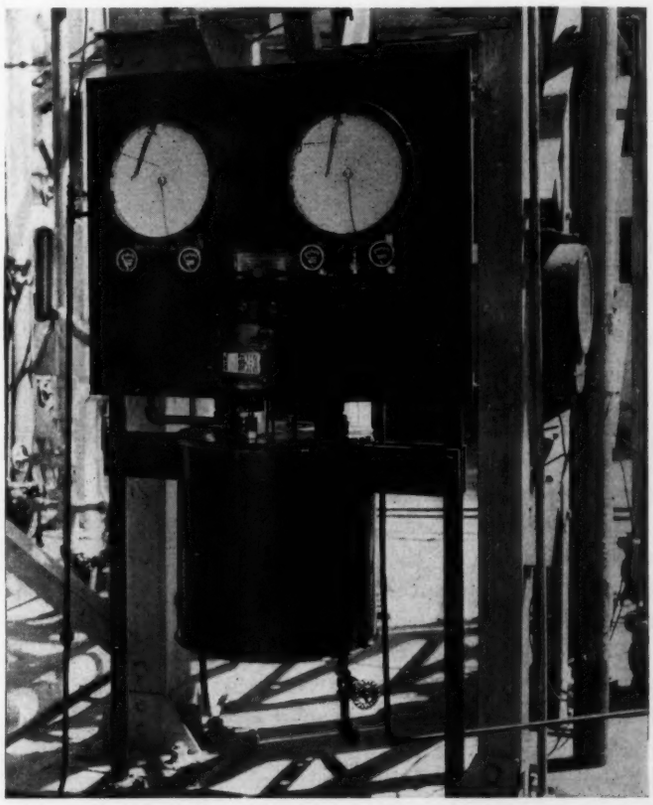
IN the average gasoline plant, successful operation depends largely upon the accuracy with which the process is carried out. This inherent necessity for accuracy has led to the use of automatic instruments for the control of temperature, pressures, and flows. Such devices are most useful when they supplement, not replace, careful human observation. In general, the design of these industrial control instruments has followed the trend of demand and has resulted in increased facilities for control of various parts of the operation.

An imposing array of continuous operating control devices which function from the properties of matter is now available. For instance, under weight measurement, we have the uniform feeding of bauxite in an alum plant, and under density control, the thickening of pulps or feeding stock to paper machines. Then under combustion control is the regulating of fuel and air supply to meet existing demands or to give a constant flue gas composition. Where conductivity can be used as a measure of composition, we find the ash in sugar being controlled, or the salts in boiler water. Then, too, control of the hydrogen-ion concentration is now effectively carried out in many industries.

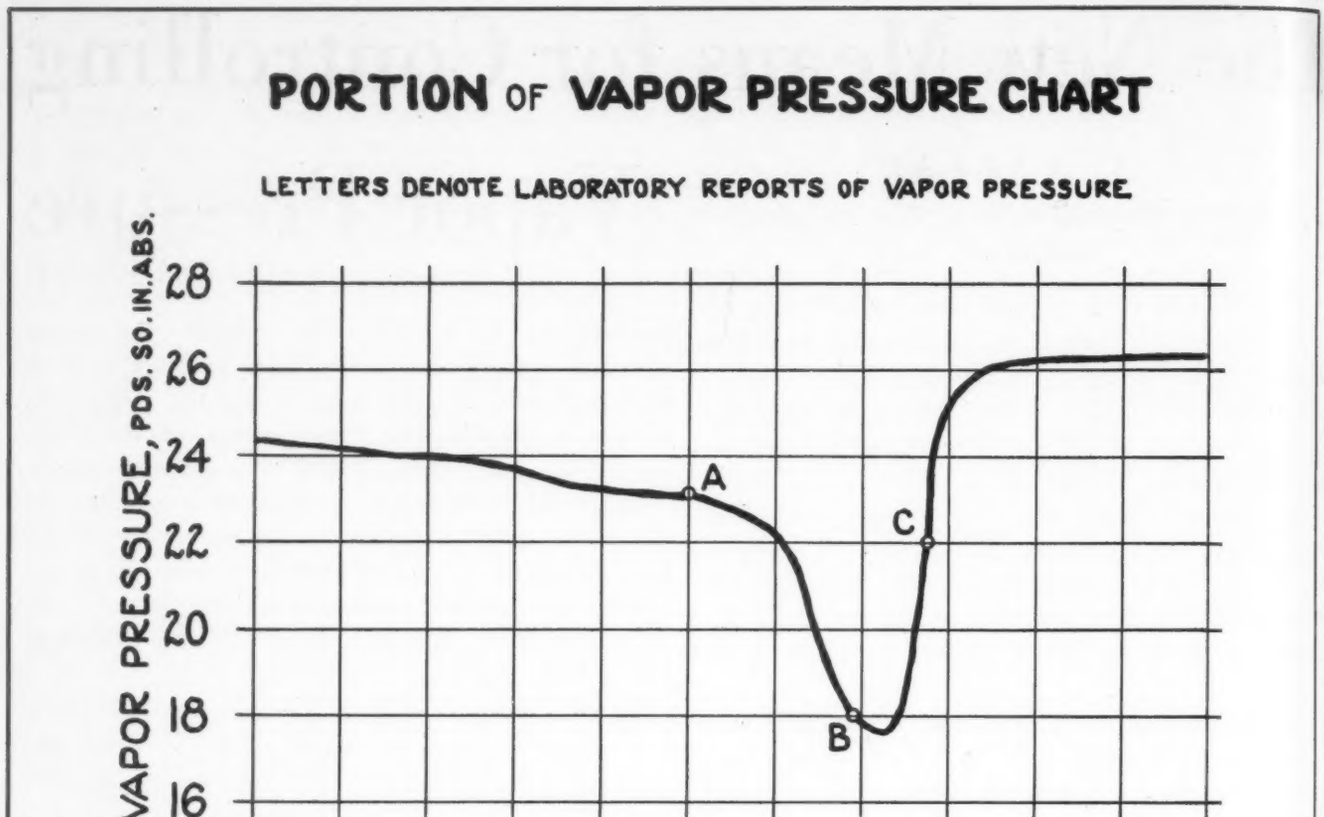
Although the above examples are far from complete, it can be stated that no controlling device functioning on this principle has ever been developed for gasoline plant service. This condition is somewhat amazing when the nature of the product is considered. Natural gasoline is sold, in the main, for its volatility characteristics, and hence its vapor pressure is used for price grading. Thus the vapor pressure, as determined by the standardized Reid method, must be controlled at all times if the maximum economic return is to be gained. The importance of control is evident when it is realized that whenever the vapor pressure of the final product drops below the specifications by as little as four tenths of a pound, a one percent loss in production volume results.

The latest development in the art of rectification, by which natural gasoline is produced, and which is now highly standardized, is in this matter of control. At this stage in development, it is the control which is of paramount importance, rather than design. For that reason, an instrument has been perfected and patented which graphically records the vapor pressure of the gasoline as it is produced. Should the vapor pressure value of the gasoline being produced start to deviate from the specification value, the instrument, through its graphic chart, immediately warns the operator of the fact. This permits the operation of the stabilizer to be immediately altered to correct for the deviation. A modification of the instrument is also available in the fully automatic form whereby it corrects or controls one variable in the unit so as to constantly maintain the vapor pressure of the product at the desired value.

Under ordinary conditions of operation, the stabilizer column is maintained under as near constant temperature and pressure conditions as possible. In addition, even the feed and reflux rates are generally automatically controlled, and were the feed always of constant composition, one could expect a constant vapor pressure product. Unfortunately, however, it is a rare case where the feed remains at a definite composition at all times, and hence, just as rare, when a constant vapor pressure product is always produced. The best



Vapor pressure recorder in a natural gasoline plant.



that can be done under these conditions is to correlate laboratory results with operating data, and develop an operating routine which will give some semblance of producing the desired product.

Such a program calls for the operators to be instructed to carry definite pressures and temperatures on the column at certain periods of the day and night. From time to time control laboratory results are reported to the operating department, who, from past experience, make such corrections in operating technique as deemed necessary. But nowhere can the operator actually resort to direct vapor pressure information. Just as better hand control resulted when recording thermometers were installed as a guide, so will better vapor pressure control result when the operator can glance at a chart and instantaneously ascertain the vapor pressure of the product. With a record of vapor pressure the operator can follow the trend. Trend is shown only on a recorder. Hand control is made easier, closer, and surer when an operator is given such a recording instrument.

The sample chart from a vapor pressure recorder is an illustration of the great advantage of a record. It shows the vapor pressure of the product under hand control without the aid of the recorder. The operator was trying, from occasional laboratory vapor pressure reports to produce a constant 22-pound product.

From the report received at "A" the operator increased the steam to the kettle in order to reduce the excessive vapor pressure. This was not only unnecessary because the vapor pressure was already falling, but it was actually causing the vapor pressure to fall to 18 pounds.

Another laboratory report was received at "B." Here the story is just reversed, and by reducing the steam supply, the vapor pressure rose to 22 pounds.

At "C," laboratory indications were that the operation was just on the dot, so that the steam supply was untouched. But the record shows that the vapor pressure was actually rising rapidly.

No operator can guess the trend in a process of this type. In every case, the action which would have been taken to maintain the vapor pressure constant using the recorder is just opposite to that actually taken from periodic laboratory reports.

Not all gasoline stabilizer operations are fit for the installation of the full automatic type of vapor pressure control instrument. Regardless of the type employed, however, the cost of the instrument is returned in a remarkably short time, sometimes through the saving of a single tank of gasoline and often within the space of a few months.

Percolation Filtration

IN THE LIGHT OF RECENT

Process Development

STANARD R. FUNSTEN

Attapulgus Clay Company, Philadelphia, Pa.

ABSTRACT

THE methods employed in applying bleaching earth to petroleum products are commonly known as "percolation filtration" and "contact filtration." This paper discusses the position of percolation filtration in modern refinery practice.

It is pointed out that the selection of the optimum method—whether it be all percolation, all contacting or a combination of the two—must be based on costs of operations with the most recent process refinements. Attention is called to the general lack of an adequate cost system for decolorization processes. A method for establishing percolation-filtration costs is outlined.

Recent refinements in the percolation process—chiefly application of engineering knowledge and methods of control—have contributed to lower costs. Improvements in clay washing, clay burning, and filter operation are discussed herein; and the importance of adequate record sheets indicated. Reference is made to an accurate method of color determination (the optical-density method) as a convenient tool for measuring work done.

The paper concludes with the expression that in the light of present knowledge it is difficult to see how the possessor of a percolation plant can afford to scrap his equipment and sacrifice inherent merits of the percolation process, such as flexibility and capacity to obtain high-quality product at low cost. Future trends of the bleaching-earth-decolorization processes and effect of the introduction of solvent-treating methods are discussed. The author expresses the view that the logical trend will be towards a combination of percolation and contacting.

Paper presented at Fourth Mid-Year Meeting, American Petroleum Institute, at Pittsburgh, Pa., May 23, 1934.

THE application of bleaching earths to petroleum refining is in general, accomplished by two methods; viz., "percolation" and "contracting." While there are many chemical and physical explanations regarding the mechanism of treatment, it is generally conceded that the phenomenon is essentially a combination of polymerization, catalytic action, entrainment, and selective adsorption. Percolation refers to the passage of oil through a bed of granular adsorbent, while contacting refers to direct agitation of oil and pulverized adsorbent. In each case the action is obtained by intimate contacting of liquid and solid.

Both the percolation and contacting methods have certain fundamental merits which make them suitable for specific refining purposes. The selection of either process will largely depend upon individual requirements. It is now becoming more apparent that a combination of these methods is desirable.

MERITS OF PERCOLATION FILTRATION

1. Efficiency and Flexibility

Gurwitsch, in *Scientific Principles of Petroleum Technology,* states: "The advantage of (percolation) filtration consists in better utilization and smaller expenditure of the adsorbent to produce a given degree of decolorization . . . . the oil comes successively into contact with a great number of very thin layers of adsorbent, the filtration is equivalent to an extremely fractionated mixing, and so its effect on the reversibly adsorbed substances must be greater than that of mixing—even when carried out in several operations with equal quantities of adsorbent." Thus percolation permits the manufacture of a wide variety of oils at one time. White oils or petrolatums of varying degrees of refinement can be processed with it equally as well as cylinder oils. Specialties can be made at little, if any, extra cost by selection of proper cuts from the filter stream. Waxes, gasoline, kerosene, and furnace oils can be clarified with revivified percolation clay at extremely low cost, since yields are very large in this type of work.

2. High Quality of Product

Oils manufactured by the percolation process are known to be of high quality as regards color stability, bloom stability, brilliancy, emulsion test, acidity, ash, carbon and sludge test, and odor and taste.

The percolation process, correctly applied, maintains substantially all of the natural bloom characteristics originally present in the oil. The natural bloom of a lubricating oil can be appreciably intensified by treatment at high temperatures by either contact or percolation. The mechanism seems to bear a very similar relation to cracking, inasmuch as the extent to which decomposition occurs is more or less proportional to the bloom intensity. Just as when substances having

bloom characteristics are produced in a cracking still, so they are produced by the catalytic and polymerizing action of clay on oil in contacting and percolation at high temperatures. Experience has shown that bloom produced in this manner is not likely to be stable.

3. Low Cost

a. *Operating*: Recent refinements in percolation, together with a more adequate understanding of filtering economics, have been reflected in substantial reduction in cost when applying the percolation process. An example is the manufacture of Mid-Continent cylinder oils. Formerly the advantages reaped by acid treatment of cylinder stock and direct decolorization were only considered possible through application of contact clays to the sour cylinder oil. Improvements in acid treating and innovation of solvent treating have made it practical now to accomplish these savings with the percolation method.

Factors often lost sight of are the facilities offered in percolation filters for washing and recovery of oil adsorption from clay. The percolation filter is naturally adapted to the leaching operation. The passage of steam and naphtha through a thick layer of clay can be accomplished without the removal of the clay after the filtering step. Provision is made for carrying away a mixture of naphtha and adsorbed oil, and vaporization of naphtha with recovered steam. The method is exceedingly efficient, and avoids high loss of viscosity oil. The oil retention of percolation clays after washing in this manner should not exceed one percent.

b. *Equipment*: Another example of improved position of percolation is that of capital expenditure required for new plant equipment. While in the past much that has been said regarding the excessive costs for equipment is true, considerable progress has been made as a result of recent percolation refinements. The field holds much of potential interest for development such as continuous counter-current percolation and continuous revivification of adsorbent.

The equipment required for a new percolation plant at the present would be of the order of 40 percent less than 10 or 15 years ago. This has been accomplished through a more intimate knowledge of time, temperature, and pressure effects in percolation and revivification of earths. Modern clay-burning equipment is being satisfactorily operated at twice its rated capacity; thousand-cubic-foot filters are being run on solution at 40 and 50 barrels an hour, as compared to the older figures of 15 to 20 barrels an hour; the rate of throughput for straight stocks has been increased, and the filter turnover time has been reduced by careful control, use of mechanical devices for charging and dumping clay, reduction of idle time, etc.

SELECTION OF METHOD FOR PROCESSING

The selection of the optimum adsorption process—whether it be all percolation, combined percolation and contacting, or all contacting—must be established on accurate cost data based on operating conditions which embody the most recent refinements known to be commercially applicable. It is unwise to accept existing plant manufacturing costs as representative of the true value of a process without preliminary study to determine whether such costs are representative of optimum operating practice. Comparisons should, of course, consider current material values, together with requirements as regards capital expenditure for new equipment. Such requirements, obviously, will depend upon the existing plant set-up.

While excellent work has been done in advancing special phases in various refineries, the industry has been backward in applying refinements to the percolation process which are known to be essential for optimum operation. The best tool available to a management for obtaining efficient operation is an adequate

TABLE 1

Filter-Turnover Costs (Per 1000 Cubic-Foot Filter)

Note: Applicable to the percolation decolorization of an acid-treated, neutralized Mid Continent cylinder stock processed as follows: 1, solution percolated; 2, dewaxed and reduced; and, 3, straight filter finished.

Type of Filter Average Clay No.	Solution 5-12	Straight 1-4
A. *Labor and general expense items—$0.5446 per 1,000 lb.	$17.97	$17.97
B. Steam for washing (25,000 lb. at $0.30 per 1,000 lb.)	7.50	7.50
C. Naphtha loss filter washing—1.8 per cent at 5 cents per gallon	4.50 (100 bbl. used)	13.50 (300 bbl. used)
D. *Fuel—clay burning	2.48	2.48
E. *Reducing filter wash	0.59	26.06
F. Clay cost (see Table 2)	29.46 (5-12 clay at $0.864 per 1,000 lb.)	43.64 (1-4 clay at $1.417 per 1,000 lb.)
Total filter-turnover cost	$62.50	$111.15

Notes:
*A. This item computed from costs allocated on a basis of clay throughput.
D. 50 lb. fuel per 1,000 lb. clay at $1.50 per 1,000 lb. fuel.
E. As follows:
1. Solution filters, reducing only 5 per cent of wash (158.2 bbl. per filter), balance to fresh solution make-up.
2. Reducing all straight filter wash (354.6 bbl. per filter).

TABLE 2

Standard Cost of Clays by Clay Numbers

Column Clay No.	A Original Weight	B Burning Loss (1.5 Per Cent)	C Net Weight Pounds	D Net Weight Per Cent of Total	E Efficiency (Per Cent)	F Product (E x C)	G Clay Costs ($ Per 1,000 Lb) "M"	G Clay Costs ($ Per 1,000 Lb) "N"	H Clay Costs (Per 1,000 Lb.) "M"	H Clay Costs (Per 1,000 Lb.) "N"
1	1,000	150	850	9.045	100	850	1.450	1.595	1.708	1.879
2	850	13	837	8.907	86	720	1.230	1.353	1.469	1.616
3	837	13	824	8.768	77	634	1.083	1.191	1.316	1.447
4	824	12	812	8.640	69	560	0.957	1.053	1.178	1.297
5	812	12	800	8.513	64	512	0.875	0.963	1.093	1.203
6	800	12	788	8.385	58	457	0.781	0.859	0.991	1.090
7	788	12	776	8.257	54	419	0.716	0.787	0.922	1.015
8	776	12	764	8.130	51	389	0.665	0.732	0.871	0.958
9	764	11	753	8.013	48	361	0.617	0.679	0.820	0.902
10	753	11	742	7.899	45	334	0.571	0.628	0.769	0.846
11	742	11	731	7.781	43	314	0.536	0.590	0.735	0.808
12	731	11	720	7.662	42	302	0.519	0.570	0.718	0.789
Total	9,677	280	9,397			5,853	$10.00	$11.00		

	Initial Cost of Clay $ Per Ton "M"	Initial Cost of Clay $ Per Ton "N"	Unit Clay Cost by Numbers (Column "H")=
Clay Cost	$12.50	$12.50	$\frac{\text{Clay Weight (C) times decimal Efficiency (E)}}{\text{F (Total)}}$ times
Freight	7.00	9.00	
Handle and Burn	.50	.50	$\frac{\text{Initial Clay Cost (\$ Per 1,000 Lb.)}}{\text{Clay Weight (C)}}$ times 1,000
Total	$20.00	$22.00	
Clay Cost $ Per 1,000 Lb.	$10.00	$11.00	

cost system. Unfortunately, but few of the domestic refineries are provided with adequate percolation costs. The following analysis is given as a means of evaluating the degree to which the various refinements in this field influence the ultimate cost of product. It is impossible in so short a time to discuss the subject fully.

ANALYSIS OF PERCOLATION COSTS

In arriving at a basis for study of percolation costs, it is desirable to consider the operation from the standpoint of work done and expense incurred in doing that work. Obviously, the unit cost for a given amount of oil will be determined to a very large extent by the amount of production or yield from a filter containing a given quantity of bleaching medium. Reduction of work to be done, or increase in efficiency of doing that work, will be reflected in larger filter yields. Yields will be increased proportionate to improvements effected in the quality of the bleaching medium. Having obtained optimum conditions for work done and means for doing the work, the ultimate cost of the filtered oil then becomes a function of the cost of operating the filter, hereafter referred to as "filter-turnover cost."

The operating cost may readily be divided into direct-expense items which are proportional to oil throughput, and direct-expense items which are proportional to clay consumption. It is necessary to prepare organization and expense schedules based on individual situations. When the fixed and variable items have been established, they may then be used in arriving at unit percolation costs for a given filter yield.

Table 1 is an example in applying the variable items for the purpose of establishing filter-turnover costs. The total cost of turning over a solution and straight filter, in this case, is shown to be $62.50 and $111.15, respectively. It should be noted that these costs are exclusive of overhead and depreciation, and do not include the viscosity-oil loss to clay or oil degradation. The calculation has been made on an empirical basis, and does not represent what is considered to be optimum for percolation. The labor and general-expense items in filter-turnover costs, as shown, represent about 50 percent of the total labor and general-expense items entering percolation operating costs. Experience would indicate that proration of these items on the basis of 75 percent to clay would represent a better average for the majority of refiners.

While it was considered in this calculation that the bleaching earth was used 12 times before discarding, it has been found in actual practice that optimum point of discarding earth, in general, ranges between five and 15 burns, depending upon the type of work to be done. Details of the method used in establishing clay values are shown in Table 2. It will be noted that the total cost of new earth, together with cost of earth required for making up losses, is charged to the process, and prorated on an efficiency basis.

Figure 1 expresses the sum of variable and fixed costs in terms of oil throughput. An example of appli-

cation is the determination of total unit costs for a given filter yield as shown below:

Example:

Required to calculate the filtration cost for Mid-Continent cylinder-oil manufacture when the average solution yield is 600 barrels per filter, and the average straight percolation yield is 300 barrels (50-gal.) per filter.

Solution percolation:

Charge to solution filters = 100 gal. viscous oil. Yield filtered oil (0.98 x 100) = 98 gal. viscous oil. Cost for 600 barrels solution filter yield (Fig. 1)—$0.0082 per gallon viscous oil charge = $0.82

Dewaxed viscous oil:

(0.85 x 0.98)—83.3 gal.

Straight percolation:

Charge to straight filters—83.3 gal. Yield bright stock (0.98 x 83.3)—81.6 gal. Cost for 300 barrels straight percolation yield (Fig. 1)—$0.0089 per gallon viscous oil charge = $0.73

Total cost for percolating 81.6 gal. = 1.55

Total percolation cost—$ per gallon oil produced = $0.019

Table 3 demonstrates the relative importance of each of the factors affecting filter costs in terms of the total filter cost.

It is interesting to note here that in no instance does the clay expense exceed 40.5 percent of the total filtering cost. Had overhead and depreciation items been included, the ratio of clay to total would be still lower. This fact, when considered on the basis of new and old clay-filter yields, is significant in the determination of the point at which a clay should be discarded. A large yield from relatively new clay may readily result in lower ultimate costs than smaller yields from older clays, even though clay expense in the latter case be substantially less.

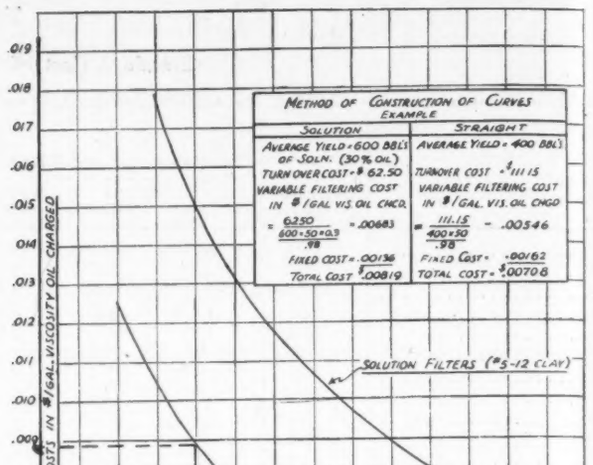

METHOD OF CONSTRUCTION OF CURVES
EXAMPLE
SOLUTION
AVERAGE YIELD = 600 BBLS OF SOLN. (30% OIL)
TURN OVER COST = $ 62.50
VARIABLE FILTERING COST IN $/GAL VIS. OIL CHGD.
= 6.250 / 600 + 50 + 0.3 / .98 = .00683
FIXED COST = .00136
TOTAL COST $.00819
STRAIGHT
AVERAGE YIELD = 400 BBLS
TURNOVER COST = $ 111.15
VARIABLE FILTERING COST IN $/GAL. VIS. OIL CHGD
= 111.15 / 400 + 50 / .98 = .00546
FIXED COST = .00162
TOTAL COST = $.00708
SOLUTION FILTERS (#5-12 CLAY)
STRAIGHT FILTERS (#1-4 CLAYS)
FILTERING COSTS IN $/GAL. VISCOSITY OIL CHARGED
AVERAGE FILTER YIELD (50 GAL BBL'S/1000 CU. FT.)

FIGURE 1

Total Percolation—Filtration Cost [Fixed and Variable]

From the foregoing analysis it may be concluded that the factors of importance in filter costs are determined by those items influencing filter yield, oil recovery, and process expense. These factors may be discussed under the following headings:

1. Type of stock and finished oil
2. Bleaching earth
3. Application of earth
4. Burning and revivification of earth
5. Other considerations

TABLE 3

Effect of Filter Yield upon Distribution of Fixed and Variable Filtration Costs, for Solution and Straight Percolation

Type of Filter	Solution* (5-12 Clays)		Straight (1-4 Clays)	
Average Yield—Barrels (50-Gal.) Per Ton	1,000	500	500	100
A. *Total filtration cost $ per gallon of viscous oil charged*	$0.0054	$0.0098	$0.0060	$0.0232
Proration of costs:				
B. *Variable costs (on clay)*	Per Cent	Per Cent	Per Cent	Per Cent
1. Clay cost	35.3	40.5	28.5	36.3
2. Labor, expense, general items	21.5	24.6	11.9	15.2
3. Steam for washing	9.0	10.2	5.0	6.4
4. Naphtha loss	5.4	6.2	8.8	11.2
5. Fuel for clay burning	2.9	3.3	1.7	2.2
6. Reducing filter wash	0.7	0.8	17.1	21.6
Total variable costs	74.8	85.6	73.0	92.9
C. *Fixed costs* (on throughput)	25.2	14.4	27.0	7.1
Total filtration costs	100.0%	100.0%	100.0%	100.0%

*70 per cent naphtha.

FACTORS INFLUENCING PERCOLATION COSTS

1. Type of Stock and Finished Oil

a. *Stock*: In the early days of oil refining the determining factor as to the quality of stock charged to the percolation plant—whether it be a neutral, cylinder, wax, petrolatum, kerosene or naphtha — was largely that of crude origin. With improved methods of fractional distillation, acid treatment, and introduction of other processes such as hydrogenation, solvent treating, vapor- and liquid-phase cracking, the picture has become much more complicated.

The application of the foregoing phases of refining in the industry has resulted in lower-colored or higher-quality stocks being delivered to the absorbent process. In each instance, however, there seem to have developed certain factors which have tended to limit their application.

Among the disadvantages of fractional distillation for overhead cylinder stock are poor-quality bloom and loss of viscosity yield. Disadvantages of acid treatment are loss of yield and high cost. With vapor- and liquid-phase naphtha treatment the tendency is now to completely eliminate preliminary acid treatment, thus reaping the advantage of increased yield obtained by percolation or contacting with adsorbent at relatively high temperatures and pressures.

The solvent-treating processes are still on the threshold of development. Among the solvent processes which have obtained substantial recognition in recent technical publications are chlorex, duo-sol, Edeleanu, furfural, nitrobenzene and phenol. In addition, propane has been used to de-asphaltize. The use of bleaching earth on solvent-treated oils has been found to improve quality, even though in a few instances it was not necessary from a transparent-color standpoint. It seems probable that solvent-treated oils will require substantial quantities of adsorbent. This, in part, may be attributed to the necessity for filtering to extra light colors in order to avoid the poor cast generally characteristic of solvent-treated oils and to the difficulty frequently encountered in removing color bodies such as are present in solvent-treated oil.

The previous history of the stock, whether it be one or all of the foregoing treatments, should always be known and considered in the determination of optimum adsorption method. The manufacturing cost preliminary to adsorption treatment is reflected very substantially in subsequent charges for oil loss and degradation.

While color of a stock is an important criterion of work to be done, there are other considerations. Stocks delivered to the percolation filter should be substantially free from moisture. The presence of water in the oil in amounts exceeding 0.1 percent is apt to be reflected in lower yields. The presence of pepper sludge in the oil preliminary to percolation is equally as disadvantageous in the percolation process as in the contacting process.

In actual practice substantial economies may often be obtained by delivering fractional cuts (obtained from the filter stream after it has reached color) to a new filter previous to charging the original darker-colored stock. However, this should never be adopted as plant practice until the advantages have actually been proved by preliminary laboratory tests.

b. *Finished oil*: While the trend in stocks delivered to absorption processes has been towards lighter colors, it is also true that the trend in specification of finished oil has been towards lighter colors. Thus, the amount of work to be done by a given amount of adsorbent has not decreased as much as one might expect.

In some cases the yield of oil from a filter is actually determined not by color, but by emulsion test, by sludge test, etc. In such cases there is often sufficient relation to permit correlation and control of the operation by color.

c. *Control*: Inasmuch as color is an outstanding measure of work done in the percolation process, it has become an important means of control. It is obviously desirable in exercising this control to employ a method which is additive in units, in order to indicate the amount of work done quantitatively. The N.P.A. color system is of little value for this purpose, since its units of value are not truly representative of color densities; e.g., one barrel of eight N.P.A. oil plus one barrel of two N.P.A. oil would mix to 6-7 N.P.A. rather than five N.P.A. The Lovibond or Tag-Robinson colors are more nearly additive. One of the most accurate methods known for measuring the true color densities of oil is described in a recent article entitled "Optical-Density Color Measurement for Petroleum Oils."[1] This method has proved very satisfactory in laboratory studies.

Supplementary processing may affect the economies of the percolation process. It is desirable, in any case, to establish a color balance starting with the original stock from crude distillation and ending with finished oil. Analysis of this type shows that frequently it is more desirable, from an overall-cost standpoint, to assume a greater color load in percolation in order to reduce excessive acid and solvent cost. Color control is found especially valuable for studying the production or accumulation of excessive color in the various distillation processes associated with percolation.

Unfortunately, from the control point of view, the amount of color removed in adsorption treatment is not directly proportional to filter yields. While the bulk of color in a given stock, in terms of color units, is readily removed, it becomes increasingly difficult to remove the last increments present. In comparing the percolation process within itself, or with another process, this fact must always be considered; and comparisons must be made on the basis of work done over the same color-removal range.

2. Bleaching Earth

The selection of an earth for percolation filtration may vary to some extent with the type of work to be done. Among the significant factors are:

a. *Activity*: This not only involves the initial ac-

TABLE 4

Approximate Temperature, Time, and Pressure Conditions for 1000-Cubic-Foot Percolation Filters

TYPE STOCK	Saybolt Viscosity (Deg. F.)	Temperature of Filtration (Deg. F.)	Rate of Filtration (Barrels Per Hour Per 1,000 Cu. Ft.)	Pressure Filtration* (Lb. Per Sq. In.)
1. Light spindles	Up to 200/100	80-100	5-25	0-25
2. Heavy spindles	200 to 500/100	100-140	5-15	0-25
3. Overhead and residual cylinder stocks	100-160/210	160-200	2-10	15-50
4. Naphtha solutions of "3"	.....	100-130	30-50	5-15
5. Petrolatums	100-160 M. P.†	25 above M. P.†	5-20	0-15
6. Waxes	100-160 M. P.†	25 above M. P.†	5-20	0-15

*Pressures in the higher range are required where 60/90 mesh earths are used.
†Melting point.

tivity of the earth, but its capacity to maintain a relatively high degree of activity upon revivification. While various abbreviated tests have been advanced for evaluating the activity of earths, none has proved as satisfactory as the application of standardized laboratory percolation.

b. *Filter-aid properties*: Earths for percolation must have characteristic hardness to permit steaming and revivification with a minimum of mechanical disintegration.

c. *Neutralization value*: It is considered a valuable attribute of a bleaching earth to possess the capacity to neutralize or adsorb acid bodies in process of filtration.

d. *Meshing*: The application of a correct meshing to perform a given job is very important. While by far the greater bulk of percolation is carried out on 30/60 mesh earths, grades are available ranging from 15/30 up to 60/90. Effect of size of particle in decolorization efficiencies seems to have been over-estimated in recent technical references. This confusion seems to have originated from lack of consideration of time of contact sufficient to obtain equilibrium of oil and adsorbent. It is well established that the actual difference in area of "outer surfaces" of a particle of absorbent is negligible, as compared to the "inner surface" available for decolorization

e. *Oil retention*: While in the case of contact clays oil retention is an important consideration, the efficient recovery of oil retained in percolation clays makes this property of relatively little significance.

3. Application and Washing of Earth

There is frequently too great importance attached to the various characteristics of filtering containers used for percolating earths. Much of the time spent in this connection would be to greater advantage if applied to clay washing and clay revivification. In general, a filter should be of sufficient strength to withstand pressures of 50 pounds per square inch. It should have a filter-bed depth of at least five feet, and the diameter should not exceed the total filter-bed depth in linear measurement. Added to this, the base of the filter should be equipped with a cone and suitable filter head (such as the Fulton or Brown type) for allowing free passage of oil. Vertical cylindrical filters seem, in general, to give as satisfactory results as tapered filters—although for white oils and petrolatums it is essential to have ample constriction at the base of the filter, in order to permit a sharper separation of oil as progressively decolorized.

Clay, in the case of lubricants, should be charged to the filter at a temperature approximating that optimum for filtration of the stock. The use of coils within the filter should be discouraged on account of tendency to over-heat and channel. The most satisfactory arrangement for maintaining heat in the filter is a well-insulated outer shell or room. Oil fed to the filter should be heated to the approximate temperature of filtration. When it is intended to produce white colors, it is well to pack the earth during filling; otherwise it is probably not justified. An automatic spreader to distribute the feed evenly into the filter is advantageous. After the filter has been filled, the earth should be leveled off, manhead closed, and oil pressure applied to hasten the soaking period—except in extreme cases, as when filtering to white colors. In such cases, gravity feed should be used. When filtered oil appears, it is advantageous to stop the flow at the base of the filter for a sufficient period to permit the entire filter to become full and soak. The time required for soaking, in general, does not exceed one hour.

Table 4 indicates in a very general way temperatures and pressures considered satisfactory for filtering various stocks. In any case, the exact condition should always be determined in pilot apparatus in order to establish the optimum. This is particularly true as regards the contact time. When the filter has reached color, it is good practice, from a throughput standpoint, to increase the filtering rate while running "off color" for re-cycle. The matter of clean separation is not so important here as the need for increasing filter turnover.

Space does not permit an exhaustive discussion of the washing process. Suffice it to say that, from a revivification standpoint, the washed clay should contain no naphtha and not more than one percent of viscous oil. Naphtha used for washing should be low-priced and of relatively narrow distillation range. Naphtha of 150° F. initial point and 380° F. end point would be

considered satisfactory. The practice of pumping naphtha through a filter without intermediate soaking and steaming is very wasteful. It is important to maintain a strict accounting of naphtha used for each filter turnover. The naphtha loss in the entire filtering and recovery process should not exceed 1½ percent. The loss of viscous oil, in general, should not exceed two percent of the oil charged. Steam used in steaming the clay should not exceed 1000 pounds per ton of clay.

It will be found very desirable to maintain accurate filter records. These records can be forwarded for supervisory consideration daily. However, it is a much better practice to summarize the data weekly in such a way as to demonstrate trends. An example of daily filter house record is shown in Figure 2.

Where the clay is to be used in vapor or liquid-phase treatment of naphthas, the operation must be adapted to this specific process. A recent article entitled "Dis-

(*Continued on page 215*)

DAILY OPERATION OF FILTER HOUSE NO._____

FOR 24-HOUR PERIOD BEGINNING 7 A. M._____19___

Filter Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
Hours Since Charging																	
Hours on Last Operation																	
Remarks / Time																	Remarks
7 A. M.																	
8 " "																	
9 " "																	
10 " "																	
11 " "																	
12 " "																	
1 P. M.																	
2 " "																	
3 " "																	
4 " "																	
5 " "																	
6 " "																	
7 " "																	
8 " "																	
9 " "																	
10 " "																	
11 " "																	
12 " "																	
1 A. M.																	
2 " "																	
3 " "																	
4 " "																	
5 " "																	
6 " "																	

Hours	Standard Time Sol.	Standard Time Str.	SUMMARIZED DATA 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Totals	Average Sol.	Average Str.
Fill Clay																					
Fill Oil																					
Run to Color																					
Run Drain																					
Blow Air																					
Wash																					
Final Steam																					
Dump																					
Repairs																					
Idle—Sol'n																					
" Straight																					
Total																					
% Oil Manhead—1																					
" " 2																					
" Composite																					
Charge Stock																					
" Color																					
Yield Bbls.																					
" Color																					
Clay No.																					

FIGURE 2

Butane . . . *a Wasted Asset of the* Petroleum Industry

R. C. ALDEN
Phillips Petroleum Company, Bartlesville, Oklahoma

AN engineer of a tank company once sought my advice about certain designs of tanks which would greatly reduce evaporation losses in the storage and transportation of crude oil. Was it true, as many informed him, that there was no point in saving the evaporation losses because the vapors were chiefly worthless butane, and could not be used even if saved? I briefly sketched the butane situation for him, concluding with the statement that it was sad, but true, that butane in crude oil was not worth saving.

Natural gasoline plants are considered extremely efficient if they extract more than 50 percent of the butane in the natural gas processed, because under such conditions all of the pentanes—and heavier—are extracted. Much of the butane extracted cannot be marketed, because it raises the vapor pressure of the motor fuel to which it is added. The butane that is not extracted could easily and cheaply be added to the motor fuel supply, because most of the investment in gathering lines and compressors is in. A relatively small investment in extraction equipment would be all that was necessary to bring the butane extraction at natural gasoline plants to 95 percent instead of 40 percent as at present. As the matter stands, the unextracted butane in the gas is sold as natural gas at about 0.2 cents per gallon.

The average yield of natural gas gasoline is two gallons for every barrel of crude oil produced, or about 1.5 gallons of pentanes and heavier. Gas royalties are paid for on the average basis of the two-gallon yield and a market price which is very much depressed due to the excess butane. If all the butane were extracted and saved, the yield could be about 3.5 gallons of natural gas gasoline per barrel of crude oil; and, if butane had a motor fuel market value, the price basis would be considerably improved.

At the refineries the cracking processes have converted large quantities of crude oil into worthless vapors. From data at hand currently, it appears that cracking processes rather generally have a butane yield of about 15 percent of the motor fuel yield. This synthetic butane is most favorably located to find its way to the motor fuel market. For present automotive fuel systems it is unwise to incorporate even this butane in the finished motor fuel. If the refiner could use all of his butane in his finished motor fuel he could reduce his crude oil purchases by very appreciable quantities.

VALUABLE RESOURCE SHOULD NOT BE WASTED

Thus, from the oil well to the filling station, butane is wastefully used or wasted because it has no motor fuel value. It is rather a shock to realize that there is enough butane to constitute 20 percent of the motor fuel supply. When we are next confronted with a shortage of crude oil, here will be a good place to make up the deficiency. In the meantime it is foolish to waste any more of this intrinsically valuable resource than can be prevented by the application of reasonably sound engineering and economic principles.

As the yield of refinery gasoline from crude oil increases, it is to be expected that the production of synthetic butane will become relatively more important than the production of naturally-occurring butane. Several years ago excessive vapor pressures in motor fuels were almost entirely attributable to butane in natural gasoline. Today many refiners have more synthetic butane than they can use in motor fuel. Unless substantial changes alter the picture, the refiners will be as ardent advocates of high vapor pressure motor fuels as were ever the natural gasoline manufacturers.

Figure 1 graphically illustrates the sources of, extraction of, and markets for butane as at present. Of the butane supply, one half is extracted and only one fourth is being used in motor fuel. Butane is easily and cheaply extracted; refinery engineers could not otherwise have justified 95 percent butane extraction in their vapor recovery plants. Butane is easily transported and handled; the experience of the liquefied petroleum gas industry demonstrates this. Butane is an ideal motor fuel; many applications to internal combustion engines have demonstrated the fact. Butane is an excellent substitute for gas and fuel oil; numerous industrial fuel users testify to the fact. Therefore, it seems logical to assert that it would pay the petroleum industry large dividends to forget about cracking, octane numbers, and new oil supplies long enough to create markets for butane. In some measure markets

for butane will partially solve each of these three perplexing problems.

Most of the difficulties in the way of extracting more butane from natural gas, apart from the fact that the markets must be cultivated, will be the same as those which now confront the natural gasoline industry. A barrel of natural gasoline can be purchased in Group 3 today at less than the price of a barrel of crude oil at the well. Yet natural gasoline is 100 percent gasoline, while crude oil must be expensively processed

TABLE 1

Differential Between Mid-Continent Crude Oil at the Well and Gasoline f.o.b. Group III Refineries—Compared with Sales Price of Natural Gasoline

YEAR	Crude Oil (Kansas-Oklahoma) (Dollars per Barrel at the Well)	Gasoline (Wholesale f.o.b. Oklahoma Refineries) (Cents per Gallon)	Differential (Cents per Gallon*)	Cents per Gallon Commanding Grade of Natural Gasoline Group III
1913	$0.934	....	....	....
1914	0.798	....	....	....
1915	0.583	....	....	....
1916	1.258	....	....	....
1917	1.775	....	....	....
1918	2.197	18.00	12.77	....
1919	2.279	17.30	11.87	....
1920	3.404	21.60	13.49	....
1921	1.731	13.80	9.67	....
1922	1.796	14.30	10.02	....
1923	1.438	9.90	6.48	....
1924	1.450	9.00	5.54	8.88
1925	1.670	10.60	6.62	12.04
1926	1.884	10.40	5.91	9.56
1927	1.285	6.80	3.74	5.70
1928	1.203	8.00	5.14	7.36
1929	1.233	7.70	4.76	6.91
1930	1.111	6.20	3.55	5.29
1931	0.573	3.60	2.24	3.04
1932	0.810	4.54	2.61	2.25
1933	0.568	3.80	2.47	2.93

*This differential represents cost of transporting crude oil to the refineries, the cost of processing, the net effects of by-product markets, plus profits in refinery operations.

to yield 50 percent gasoline. Apparently oil company executives cannot be made to realize that gasoline can be extracted from natural gas more cheaply than it can be made from crude oil. The fact that the natural gasoline industry has been able to pay 30 percent royalty back into the petroleum industry's pocketbook and still market its gasoline at a long-time average price of one cent per gallon under the commanding grades of refinery gasoline, should be convincing evidence of the relative costs of manufacture of gasolines from the two sources.

In this connection the data in Table 1 are interesting. The differential between the price of refinery gasoline, f.o.b. Group 3, and the price of Mid-Continent crude oil at the well has declined from 10 cents to 2.5 cents per gallon since 1921. When these differentials (yearly averages) are plotted chronologically, a definite trend becomes apparent—with the differential approaching a constant value of about three cents per gallon. Thus it is obvious that with a price for crude oil at the well

ABSTRACT

THERE is enough butane available to constitute 20 percent of the motor-fuel supply, as compared with a present-day average content of about six percent. With the advent of cracking large quantities of crude oil have been converted to synthetic butane. The amounts of synthetic butane are so large that modern refineries now have much more available than can be incorporated in finished motor fuels. The natural gasoline industry is in dire distress because of the depressing effect of this excess butane on its market.

Several minor markets—such as direct motor fuel uses, large stationary engines, industrial fuel uses, and the new light trains—are already being exploited.

The most direct use is to blend as much butane as possible in conventional motor fuels. The first step in this direction is for refiners to crowd prevailing seasonal maximum Reid-vapor-pressure specifications. The second step is to enlist the automobile industry whole-heartedly in a campaign to eliminate the poor plumbing that makes a few models very bad vapor lockers. The maximum permissible butane content of motor fuels should be limited by evaporation and quality losses, rather than by the poor design of fuel systems in a few models.

Due to its sponsorship of the "octane-number race" the automobile industry should now lend its utmost cooperation to minimizing this economic waste. An incidental advantage of high-octane-number gasoline which has not been utilized by the automobile industry is the improvement in volatility which has coincided with the improvement in antiknock characteristics.

The economic waste of butane has three phases: 1, crude oil must be produced to offset the waste; 2, the butane has a very low value except in motor fuel; and, 3, butane added to motor fuel reduces ethylizing expenses. It is estimated that each one percent of butane added to motor fuel will reduce expenses at the refineries by $11,600,000 annually. In addition, an otherwise waste material will have a market value of $8,800,000 annually. Thus, with obvious and simple improvements in the fuel systems of a comparatively few car models, the petroleum industry can effect economies in the motor fuel supply amounting to $50,000,000 annually.

Except for the facility in meeting seasonal variations in butane content, natural gasoline butane is at a heavy handicap due to its relative remoteness from the ultimate consumer. There is the definite possibility that strict accounting would show that natural gasoline butane could be laid down at the refinery for less than the cost of the crude oil from which the synthetic butane is made. Additional quantities of natural gasoline butane could be economically added to the liquid fuel supply, provided markets were established. As gasoline yields from crude oil rise and fuel oil yields decline, natural gas butane may become an important factor in retaining this source of revenue for the petroleum industry.

Paper presented at Fourth Mid-Year Meeting, American Petroleum Institute, at Pittsburgh, Pa., May 24, 1934.

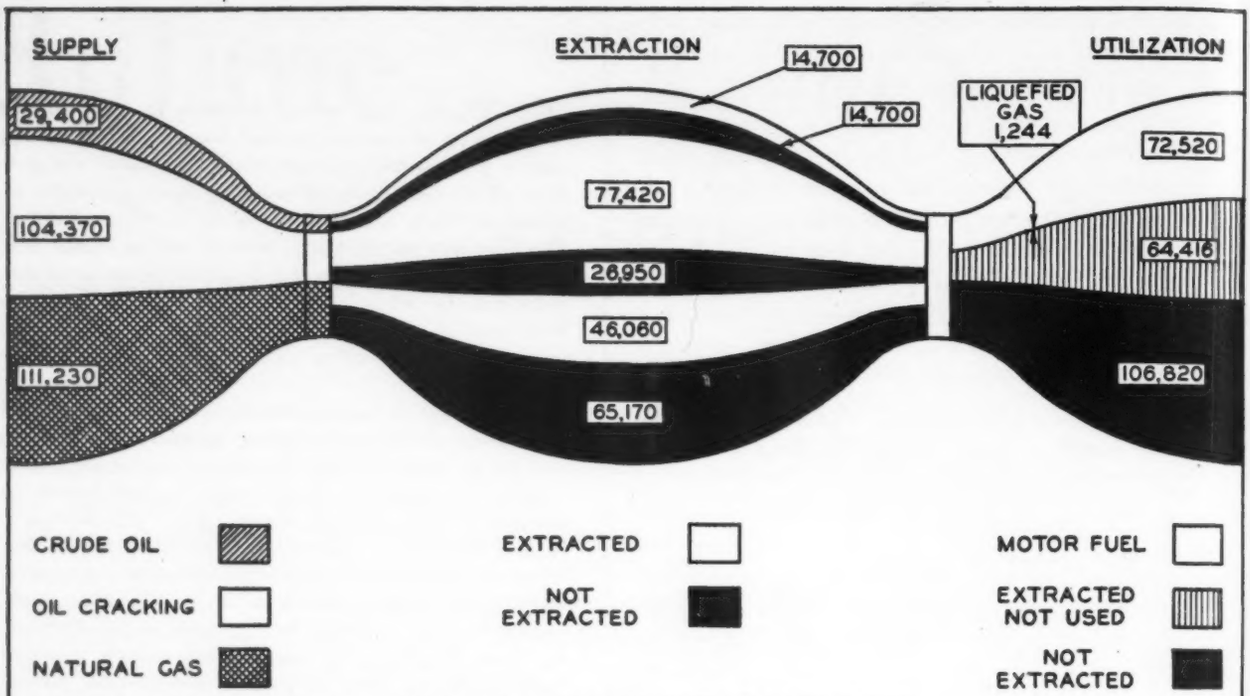


FIGURE 1

An Approximation of the Butane Supply and Demand. (Barrels Per Day)

satisfactory to the marginal producers, refinery gasoline must bring about six cents per gallon to permit refinery operations to be profitable.

The significant feature of Table 1 is that the differential alone is about equal to the past two years' average market price for natural gasoline. In other words, during the past two years natural gasoline was sold at about the cost of transporting and processing crude oil to produce refinery gasoline. Out of this low sales price for natural gasoline, a substantial proportion was returned to the oil industry in the form of royalty payments.

In spite of the obvious conclusions to be reached from these well known facts, the natural gasoline departments of many integrated companies struggle for existence—chiefly against accounting systems established primarily in behalf of the more influential crude oil production and refinery departments. These accounting systems cannot take cognizance of the fact that, in spite of its relatively low price, natural gasoline is a motor fuel almost ready for the market; while crude oil is a raw material requiring transportation, processing, and disposal of by-products. The spot market quotation on a few tank cars of distress natural gasoline is the basis on which these accounting systems appraise this, the cheapest source of motor fuel.

Because the petroleum industry has already invested in gathering lines and compression units to bring natural gas into central points, it is a safe assertion that additional butane could be extracted at gasoline plants at a lower real cost than prevails for commercial natural gasoline at the present time. With a little more investment, considerably more gallons could be produced. Yet it is certain that complications in inter-departmental relationships in the major companies would continue to serve as an obstacle—granting there was an intensive effort made to cultivate the markets for butane.

PAST AND PRESENT SUPPLIES INDICATED

Figure 2 is an attempt to show graphically the past and present butane supplies. The relative importance of natural and synthetic butane is rapidly changing. The fundamental factors are: 1, the percent of butane-free motor fuel obtained per barrel of crude oil run; 2, the percent of available butane in the motor fuel produced; 3, the effect of several butane extraction efficiencies at the refineries and at natural gasoline plants; and, 4, the butane content of motor fuels. In each of the three charts factors (1) and (2) are the abscissae and ordinate, respectively.

Chart A shows the percent of butane in the motor fuel produced, available from natural gas at several butane-extraction efficiencies. The amount of natural gasoline produced per barrel of crude oil produced has been constant at about two gallons since 1926. Hence, as the yield of refinery gasoline from crude oil increases, the proportion of natural gasoline in the total motor-fuel supply will decrease. The heavy dotted line on chart A is the writer's estimate of the progress of butane extraction at gasoline plants corresponding to progress in gasoline yields at refineries. From chart A it is to be observed that the contribution of natural-

gasoline butane to the potential butane content of motor fuel is on the decline. It is to be expected that this will continue unless the butane markets are greatly amplified.

Chart B shows the percent of butane in the motor fuel produced, available from crude oil at the refineries at several butane extraction efficiencies. The bases of these calculations is that straight-run gasoline contains five percent butane, that cracked gasoline contains 17 percent butane, and that the first 25 percent of the crude oil yield is debutanized natural and straight-run gasoline. The heavy dotted line is the writer's estimate of the progress of butane extraction at refineries corresponding to gasoline yields from crude oil. From chart B it is to be observed that the contribution of refinery butane to the potential butane content of motor fuel has rapidly increased, and will slowly increase.

Chart C combines the heavy dotted lines of charts A and B, and includes the writer's estimate of the butane content of motor fuels of the past as related to progress in yields of gasoline from crude oil. It is to be observed that in the days of low gasoline yields from crude oil there was not much more butane extracted than was needed. Then the natural gasoline industry increased its butane extraction, and there was surplus butane in terms of prevailing concepts of motor fuel quality. Today many refineries are capable of 95 per-

TABLE 2

Effect of Butane Content of Motor Fuel on National Crude Oil Requirements

Natural Gas Butane Used (Per Cent)	Refinery Butane Used (Per Cent)	Butane Content of Motor Fuel (Per Cent)	Crude Oil Per Day (Barrels)	Per Cent Less Crude Oil Requirements (Per Cent)
30	38	7.0	2,400,000	0
40	73	12.0	2,271,000	5.4
50	100	16.0	2,173,000	9.5
100	100	20.0	2,065,000	14.0

cent butane extraction, and there is consequently a large excess of butane. Concepts of motor fuel quality have changed so that maximum vapor pressure specifications are being crowded, particularly in the summer time.

Chart C also shows the effect of various increments of the butane supply on the Reid vapor pressure of the average motor fuel. It is to be noted that if refiners were to use all of the butane now extracted from refinery vapors, plus the butane now marketed in natural gasoline, the average Reid vapor pressure of motor fuel would be about 12 pounds.

It is obvious from chart C that natural-gasoline butane is at a heavy handicap, since refineries are capable of incorporating 13 percent butane from their

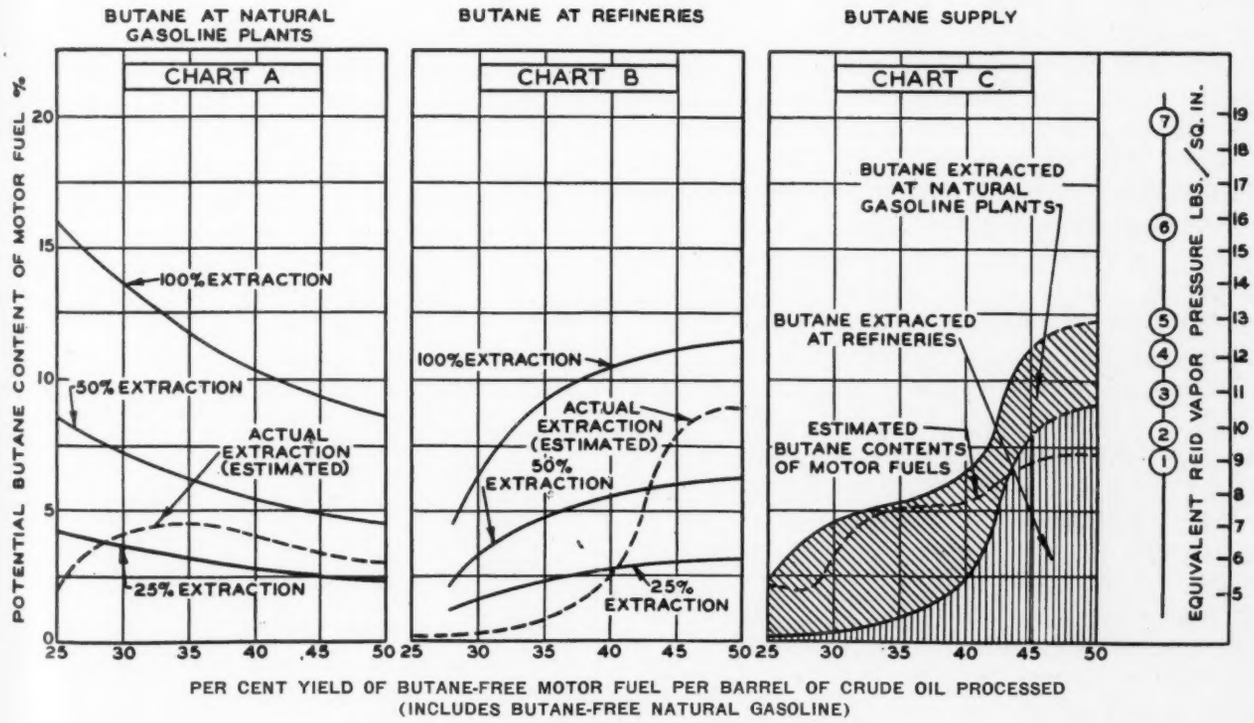

BUTANE AT NATURAL GASOLINE PLANTS
BUTANE AT REFINERIES
BUTANE SUPPLY
CHART A
CHART B
CHART C
POTENTIAL BUTANE CONTENT OF MOTOR FUEL %
100% EXTRACTION
50% EXTRACTION
ACTUAL EXTRACTION (ESTIMATED)
25% EXTRACTION
BUTANE EXTRACTED AT NATURAL GASOLINE PLANTS
BUTANE EXTRACTED AT REFINERIES
ESTIMATED BUTANE CONTENTS OF MOTOR FUELS
EQUIVALENT REID VAPOR PRESSURE LBS./SQ. IN.
PER CENT YIELD OF BUTANE-FREE MOTOR FUEL PER BARREL OF CRUDE OIL PROCESSED
(INCLUDES BUTANE-FREE NATURAL GASOLINE)

FIGURE 2

Butane Supply—Past and Present

Numbers on scale just to right of chart C indicate annual average vapor pressure and butane content of motor fuel at refineries under the following conditions:

1—Present day motor fuels.
2—Inclusion of all butane currently extracted at refineries.
3—All marketers crowding present day federal specifications.
4—Inclusion of all butane currently available at refineries.
5—Possible and practical with a reasonable improvement in automotive fuel systems.
6—Inclusion of all butane available at refineries plus 50 percent of the available natural gas butane.
7—Inclusion of all butane available at refineries and from natural gas.

own vapors. Some refineries still do not make synthetic butane, or do not extract butane; and these still provide some market for natural gasoline butane. The only thing that can make natural gasoline butane a sound commodity is to elevate the permissible butane content of motor fuel to nearly that obtainable in the average refinery operation. Then there will be enough refineries below the average to create a market value for natural gasoline butane.

Table 2 shows the estimated effect on national crude oil requirements of utilizing various increments of the butane supply in motor fuel. Every barrel of butane added to the motor-fuel supply saves about 2.5 barrels of crude oil. For a pound increase in the average Reid vapor pressure of motor fuel, crude oil requirements are reduced about 1.25 percent.

BUTANE THE MARGINAL HYDROCARBON

From the facts which have been presented, it can be seen that butane has become the marginal hydrocarbon in the manufacture of motor fuels. The development of cracking processes has shifted the emphasis from the heavy to the light hydrocarbons. Gasoline yields from crude oil are no longer dependent on the end point of the motor fuel, because cracking processes can cheaply and easily convert the high boiling fractions to fractions well within the gasoline boiling range. The problem of the refiner now is to crowd as much butane into gasoline as possible to reduce refinery losses, to raise gasoline yields, and to improve the motor fuel.

Apart from the economic necessities for increasing gasoline yields from crude oil, the "octane number race" has been largely responsible for the rapid development of the cracking processes. The automobile industry has been the chief inspiration of this expensive race. As interpreters of public demand, the automotive industry has insisted that improvement in anti-knock qualities of gasoline was an absolute requirement in stimulating the universal dissatisfaction with last year's models so necessary to sales of current model.

The automobile industry has gone to great expense to build high top speeds into cars. The oil industry has gone to great expense to produce gasolines of high octane number so that the motoring public may enjoy the high top speeds. Both industries have overlooked the following incidental results which may be more important than the results sought:

1. High-octane gasoline is much more effectively volatile than low-octane gasoline. By design of suitable fuel-induction systems this may lead to as important results as high compression engines.

2. An economic waste has been created by virtue of the fact that large quantities of crude oil are being converted to butane. It is possible to design automotive fuel systems so that much of this waste can be prevented.

CARS ARE V. L. OFFENDERS

For five years the automotive and petroleum industries have fostered a cooperative investigation of the vapor-lock problem. The investigation has been cooperative, but there the cooperation has ended. Although it has been known for several years how to design fuel systems for automobiles so vapor lock would be impossible, each crop of new models has shown the same tendency to vapor lock. *There has been no improvement in the cars.* Is this cooperation? It is time for the petroleum industry to place the blame for vapor lock squarely where it belongs—on the offending cars.

Our marketing department has recently had an interesting experience in this type of education. One of our good customers, operating a fleet of 400 taxicabs, complained of vapor lock troubles early in the spring. The 400 cars were a wide assortment of makes and models, most of them in the middle- and high-price range. It was reported that 25 of the cars were bad offenders, and 50 others gave occasional trouble.

Representatives from the motor fuel laboratory and the automobile department were dispatched to the scene of action, with instructions to correct the fuel systems of the offending cars as much as possible. In the course of 10 days, 43 cars were worked over at an average cost of about $2.50 for labor and material.

It is certain that a few of the 43 cars will continue to give some vapor lock trouble, but it is likewise certain that most of these cars have been cured of this embarrassing difficulty. The important thing, however, is that this customer has been shown the terrible plumbing in some cars as compared with sensible design in others. Henceforth when 400 drivers encounter vapor lock—or anything that resembles vapor lock—it will be the automobile that gets cussed out, and not the gasoline nor the weather.

In general, the petroleum industry has not taken the utmost advantage of seasonal and geographic distribution of gasoline to utilize its butane resources to the best advantage, even under the adverse conditions of poor fuel-system design. There is still a decided ten-

TABLE 3

Average Reid Vapor Pressures of Summer and Winter Branded Gasolines in the Mississippi Valley

Company	Reid Vapor Pressure			Total Samples
	Winter*	Summer†	Difference	
1	11.66	7.48	4.18	95
2	10.66	7.11	3.95	26
3	11.34	7.47	3.87	11
4	11.54	7.70	3.84	54
5	10.80	7.41	3.39	27
6	10.04	6.75	3.29	32
7	11.06	7.87	3.19	47
8	10.84	8.06	2.78	19
9	9.86	7.26	2.60	31
10	10.12	7.68	2.44	11
11	10.17	8.20	1.97	20
12	9.72	7.81	1.91	47
13	9.49	8.15	1.34	49
14	8.91	7.58	1.33	13
15	9.17	7.90	1.27	14
16	8.33	7.50	0.83	7
Miscellaneous	9.95	7.18	2.77	37
Total....	10.46	7.57	2.89	540

*Winters 1932-33, 1933-34.
†Summer 1933.

dency toward winter motor fuels of low vapor pressure and, hence, of low butane content. Table 3 shows the average Reid vapor pressures of summer and winter branded gasolines in the Mississippi Valley. It is to be noted that although the summer gasolines are close to the accepted summer maximum vapor pressure of eight pounds, the winter gasolines are frequently much below the accepted maximum limit of 12 pounds.

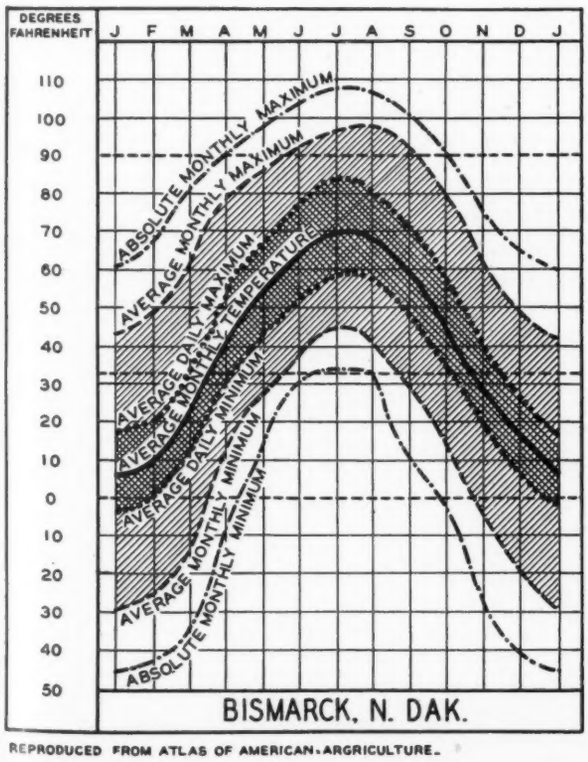
Crowding the seasonal vapor-pressure specifications should result in a vapor-pressure difference of four pounds between the summer and winter gasolines. Yet only one company's products showed this difference, with but three others close to it.

It is a comparatively simple matter to establish shipping schedules for seasonal and geographical distribution of motor fuels with maximum vapor-pressure specifications so as to include as much butane as possible, and at the same time minimize vapor lock and keep evaporation and handling losses down. Vapor lock and evaporation losses are both greatly influenced by atmospheric temperatures. Through the several researches that have been conducted in these fields, it is comparatively simple to relate vapor pressure specifications of motor fuels to atmospheric temperatures.

For those who might be interested in a very thorough analysis of seasonal and geographic distribution of atmospheric temperatures, reference is made to the ATLAS OF AMERICAN AGRICULTURE, Part II, *Climate*, Sect. B: "Temperature, Sunshine, and Wind," by Joseph B. Kincer, issued November 1928.*

Figure 3 shows a typical chart of the annual march of temperatures for one locality. It is to be observed that, regardless of the particular temperature basis chosen, the seasonal trend is about the same. Hence it makes very little difference whether maximum, monthly maximum, or mean maximum temperature is chosen as the criterion for vapor lock—provided everyone understands the basis adopted and its significance.

*Obtainable from Superintendent of Documents, Government Printing Office, Washington, D. C., at $1.60 per copy.



REPRODUCED FROM ATLAS OF AMERICAN AGRICULTURE.

FIGURE 3

One very important characteristic of butanes is their high "blending" octane numbers of about 90. They are very effective in blending and ethylizing. For a detailed study of the T.E.L. (tetraethyl lead) values of the light hydrocarbons, reference is made to the paper presented by Neptune and Trimble at the recent Tulsa convention of the Natural Gasoline Association of America. Table 4 shows the extent to which normal butane can reduce expenses in ethylizing gasolines. As a generality, butanes at the point of ethylizing are worth a premium per gallon over the stock to which they are added of 3.5 to 4.0 times the cost of ethylizing the stock to which they are added.

TABLE 4

T.E.L. Requirements for Normal-Butane Blends With a Wide Variety of Debutanized Refinery Gasolines

(To Any Octane-Number Specification)

Percentage of Normal Butane

0	5	10	15
1.00	0.80	0.50	0.30
1.50	1.20	0.80	0.55
2.00	1.55	1.10	0.80
2.50	1.95	1.40	1.00
3.00	2.30	1.75	1.25
4.00	3.05	2.35	1.75
5.00	3.80	2.95	2,20
6.00	4.55	3.60	2.70

ECONOMIC PRESSURE FELT

The economic pressure of the large butane supply which has been described is already beginning to manifest itself in the motor-fuel markets. The most radical departure is to be found in California where several campaigns are in progress to market butane directly as a motor fuel. It is said that 1400 trucks and buses and 2200 tractors and farm engines are equipped to use butane as a motor fuel. A butane dispensing station is reported under construction at Oakland. Conditions in California are ideal for such applications, but it is certain that the plan will be tried in other localities. In the end there will be a definite and limited field for butane as a direct motor fuel in highway transportation.

Butane is an excellent fuel for the new light trains, and has been so used with very good results. If this type of transportation increases, it should provide a market for butane.

Large stationary engines is another field where butane offers advantages. Progress has been made in this field also.

Another field for butane as a motor fuel will be

among that fringe of gasoline marketers who can afford to vapor lock a few car models. It is to be expected that butane will be cheap for a long time to come. Under such circumstances the jobber will be able to purchase butane to blend with other cheap gasolines and, thus, will have a price advantage over his more conservative competitors. Undoubtedly, the present low-price era in the natural gasoline industry is at lease partly due to this condition. Natural gasoline is merely a carrier by means of which the opportunists get butane into motor fuel at only the costs of transportation. Some refiners have actually accelerated this trend by placing vapor-recovery gasoline, loaded with refinery butane, on the market.

The largest field for butane as a motor fuel is in the gasolines of the major marketers. Present-day winter gasolines have not gone up to the safe limit for the cars now on the road. Thus some saving of wasted butane could be made if gasoline manufacturers more generally adhered to seasonal maximum Reid vapor pressure specifications.

To accomplish substantial utilization of the waste butane, it will be necessary to obtain the whole-hearted cooperation of the automotive industry to the end that the fuel system design will no longer be a factor in the utilization of butane. In other words, all cars should be incapable of vapor lock. Then the butane content of filling station gasolines could be raised as rapidly as was jutifiable from experience in respect to evaporation losses, and maintenance of quality as a result of evaporation losses.

If the automotive industry were to determine on such an objective immediately—so that no more models would appear that were susceptible to vapor lock—the assistance of the accessory people could be enlisted to cure the old models of vapor-locking tendencies. It would not be very long before evaporation and handling losses would exercise the chief limitation on the butane content of motor fuels.

RESULTS TO BE ACCOMPLISHED

In conclusion, it is worth repeating that each increase of one percent in the butane content of filling station gasoline will have the following effects:

1. Will raise the Reid vapor pressure of the motor fuel about 0.8 pound.

2. Will lower crude oil requirements 1.25 percent, or about 30,000 barrels per day. At $0.94 per barrel, this amounts to $10,293,000 annually. In addition, the lessened demand for crude oil should reduce the price of all crude oil.

3. Will reduce refinery losses or increase refinery yields by about 12,000 barrels per day. At 4.8 cents per gallon, this amounts to $8,830,000 annually.

4. Will reduce the cost of ethylizing by about five percent. With 70 percent of the motor fuel ethylized, with an average T.E.L. content of 0.6 cc. per gallon, this saving amounts to about $1,341,000 annually.

5. The total reduction in refinery expenses for items (2) and (4) is about $11,600,000 annually for each added one percent of butane.

If the butane content of motor fuel could be raised five percent, there should be a saving of about $55,000,000 annually. How much of this saving would be passed on to the motorist is problematical. If past history is any criterion, the consuming public will get more than its share of any advances made by the petroleum industry.

It cannot be too strongly stated that poorly designed fuel systems on a few car models are responsible for a large part of the current waste of butane. These few cars make it necessary to restrict the butane content of all motor fuel. In view of the petroleum economics involved, it can no longer be stated that vapor lock is due to the gasoline or to the weather—it is due to poor engineering in the design of automotive fuel systems.

At the insistence of the automobile industry the refiners have made high-octane-number gasoline which, incidentally, has a high effective volatility and a high butane content. It certainly is fitting that the automobile industry should make a real attempt to utilize both of these incidental advantages so that the motoring public may reap the full advantages of the progress that has been made.

The writer is indebted to T. W. Legatski for helpful suggestions in respect to the construction of the charts, and to W. H. Wood for the colored slides reproduced from the *Atlas of American Agriculture*.

Percolation Filtration in the Light of Recent Process Development

(*Continued from page 207*)

tillate Treating now Highly Developed and Simplified."[2] describes this subject in detail; and will, therefore, not be further discussed here.

The handling and storage of the filtered oil deserves consideration. It is often advantageous where the oil is filtered hot, to pass it through coolers immediately after filtration—before reaching storage.

4. Burning and Revivification of Earth

Not enough attention has been paid by most refiners to the question of burning and revivification of earth. Efficiency in revivification is not measured by the number of times a clay is re-used, in spite of the somewhat too prevalent idea. It has been found that some refiners have been using clays 35 to 40 times before discarding, whereas they would be far better off had the clay been discarded after eight or 10 burns. A factor which has tended to cloud the case, in such instances, is the use of new clay for make-up—thus effecting higher levels of efficiency than otherwise would have been the case.

Even with optimum clay burning it has, in general, been proved that the lowest cost is reached after comparatively few burns. The reason for this may readily be understood when it is considered that the average material cost for earth when revivified 10 times is about $3.00 per ton for each turnover, including cost of make-up clay.

The mechanics of determining the point at which clay is to be discarded varies for individual conditions. A careful study must first be made to establish the relative clay efficiencies (assuming new burned clay equals 100 percent) up to point of discarding. This work can best be done by laboratory evaluation of plant-burned clays. From these efficiencies the cost of

CLAY BURNING LOG SHEET

Period_____ 24 Hours Ending_____7 A. M._____19_____
House No._____ Kiln Type_____ Kiln No._____

Time	Clay No.	Clay Code	Bin Number From Bin No.	Bin Number From Filt No.	Bin Number To Bin No.	Bin Number To Filt No.	Rate Tons/Hr.	Hearth Temperature of #2 Rotary	Hearth Temperature of 3	Hearth Temperature of 4	Hearth Temperature of 5	Burned Clay % Vm	Burned Clay Wt.(Lb. Per Cu. Ft.)	Signed
7 A. M.														
8														
9														
10														
11														
12														
1 P. M.														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
1 A. M.														
2														
3														
4														
5														
6														

Miscellaneous Data
Total Tons Burned____24 Hours_____Tons/Hr._____Remarks
Total Time Repairs_____
Total Time Idle_____
Total, Fuel Consumed Gals._____Gals. Ton
Code R Repairs L Idle O Wet Clay

FIGURE 3

clay for any given number of uses can be established as shown in Table 2. Filter-turnover costs must then be calculated as in Table 1, applying the foregoing clay cost. In addition to items included in filter-turnover costs there should be a debit for viscosity-oil loss to clay or degradation. The total unit cost for any given number of uses may then be determined in a manner similar to the example shown on page four. When the final unit cost of a product for a given number of revivifications is found to be but a fraction of a cent different from the cost for lesser number of revivifications, it is generally advantageous, from the refiner's point of view, to discard clay at the earlier point in order to obtain greater throughput, and, in some instances, somewhat higher quality of product as a result of employing the younger and more efficient clay.

The conditions for burning granular clay, whether new or used, must be such as to avoid local over-heating. In any case, the adsorbent should not come into direct contact with fire from the furnace. The time, temperature, and atmospheric conditions in burning clay should be such as to permit the complete removal of organic compounds, together with uncombined water—without releasing the combined water or altering physical structure or chemical composition. Temperatures employed for revivifying clays in refinery practice vary from 900° F. to 1350° F. Time of clay contact with heat is found to vary from one half-minute to four hours. Strangely enough, those practicing the extremes seem equally assured of optimum operation.

Carefully carried out experimental tests on used clay indicate that best results can be obtained when maintaining a temperature of 1100° F. to 1200° F. (clay temperature) for a period of at least 15 minutes in a relatively rich oxidizing atmosphere.

Raw clay, in general, may be satisfactorily burned when maintaining temperatures of clay not exceeding 900° F. for at least 15 minutes. By "clay temperature" is meant the actual temperature as determined by thermocouples moving in the clay. While it is possible to establish a rough correlation from gas temperatures in the kiln, or from stationary thermocouples resting in the clay, such procedure cannot be depended upon.

An important factor in obtaining results in percolation clays is to avoid storage following the burning of the clay. Best results are obtained when the clay is conveyed directly to the filters.

An outstanding refinement which is being applied at the present time in some refineries is technical control of the clay-burning operations. This is done by application of standard methods of tests to the clay before and after burning. These tests include: 1, determination of oil content of unburned clay; and 2, determination of volume weight and volatile content of the burned clay. The relation of weight and volatile content of a given bleaching medium has been found to correlate very closely to the bleaching efficiency. Increase in weight with revivification should be held to a minimum. As a matter of added protection, it is desirable to make periodic laboratory pilot percolation tests using standardized percolation methods. In this connection, recent studies have definitely proved that results of tests carried out in accordance with standard laboratory equipment check very closely with those obtained under similar conditions in plant percolation filters.

In general, a raw clay should be burned to a volatile content of four percent. With this volatile content the actual weight in pounds per cubic foot, as determined by standard tests, will range between 33 pounds and 36 pounds for the average Florida-Georgia 36/60 mesh clay. The volatile content of used clays after burning should not be less than two percent.

Another step in control of efficiencies, in the clay-burning operation, is the maintenance of accurate records. A form of clay-burning record is shown in Figure 3.

5. Other Considerations

In the selection of a method of manufacture it is essential that a study be made for purposes of obtaining the optimum combination for processing a given oil. For instance, it may be desirable to combine acid treating with percolation or contacting with percolation.

When color is partly removed in cylinder stocks preliminary to dewaxing and finally removed in finishing after dewaxing, it is important to determine the optimum amount of color to be removed in the respective decolorization steps. Such a determination can be made by means of a combination of experimental data with cost analysis such as has been presented in the foregoing discussion.

FUTURE TRENDS

When one considers the percolation process and its potentialities in the light of recent developments, it is difficult to see how the possessor of a percolation plant can afford to scrap his equipment, thereby sacrificing the inherent flexibility and capacity to obtain high quality product at low cost. Both the percolation and contacting methods have merits which should be evaluated on the basis of individual requirements. It is felt that the logical trend in future processing will be directed towards a combination of the percolation and contacting methods.

BIBLIOGRAPHY

[1] S. W. Ferris and J. M. McIlvain, *Ind. Eng. Chem.*, **6**, 23 (1934)

[2] M. B. Cooke and A. W. Hayford, *Refiner Natural Gasoline Mfr.*, **13 no. 3**, 83 (1934).

THE PROBLEM *of the* Viscosity of Lubricants

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ABSTRACT

PARTICULARLY in research and engineering work more accurate measurements of viscosity are needed. This is not only because lubricants are being investigated more comprehensively, but also because new problems are arising involving materials which were of no previous concern to lubricant developments. If better methods of measurement are to be used, it is logical to express the results in fundamental viscosity units. This does not require that the Saybolt second fall into disuse, but only that ultimate decisions concerning viscosity values be based on fundamental viscosity units, and that the Saybolt second be defined in terms of such units and not exist as a separate identity.

During the past two or three years considerable experience has been obtained using modified Ostwald viscometers to measure viscosity in kinematic units. The design, construction, and operation of these are described in detail. In addition the relationship between Saybolt and kinematic viscosity has been studied to facilitate the expression of the data into the widely accepted units of Saybolt seconds. Temperature-viscosity data for light oils have also been obtained for the purpose of establishing more accurate viscosity-index tables for light oils.

Paper presented at Fourth Mid-Year Meeting, American Petroleum Institute, at Pittsburgh, Pa., May 24, 1934.

ACCURATE viscosity determinations are of major importance in any systematic investigation of the viscous fractions of petroleum. Not only is viscosity a common method of comparing oils, but it is a property closely related to the practical value of the oil as a lubricant. This paper summarizes the development of apparatus for the rapid and accurate measurement of viscosity, and in addition data are presented on the viscosity-temperature characteristics of light Pennsylvania oils.

MEASUREMENT OF VISCOSITY

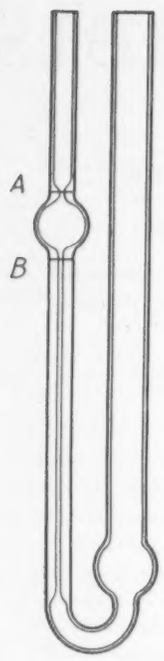
It was decided that the desired viscometer should possess an accuracy of the order of 0.2 percent. It should require only a small amount of oil, say 5 cc. to 10 cc., since in research problems it is frequently inconvenient and expensive to obtain larger samples. The viscometer should be simple, accurate, and inexpensive; and require the minimum of auxiliary apparatus. It was also decided that the results should be in fundamental units of viscosity having definite and universal meaning, and not in any one of the several arbitrary units that are in use. This is desirable from the practical point of view, since all frictional problems in mechanics are solved on the basis of absolute viscosity. Also there is considerable agitation by various authorities on viscosity measurements[1] to have all results presented in the same absolute units, and thus avoid the present difficulties and inaccuracies in comparing results of different workers.[2]

The Saybolt viscometer is too well known to require comment. Viscometers of the torsion type,[3] or the falling-sphere type, require too large a sample of oil, and are not readily adapted to viscosity measurement at various temperatures. The capillary-tube type, of which the "Ostwald viscometer" (Figure 1), or a modification of it, is a common form, meets most of the requirements. However, no one viscometer of this type which incorporated all the desirable features was available, or was described in the literature. Among the advantages of this type may be mentioned:

1. Only 5 cc. to 10 cc. of liquid required.
2. Several determinations can be made with the same sample with a minimum of handling.
3. The experimental error in determining relative or absolute viscosities can be made very small.
4. The determination can be made at any temperature with almost equal ease.
5. The viscometer is inexpensive.

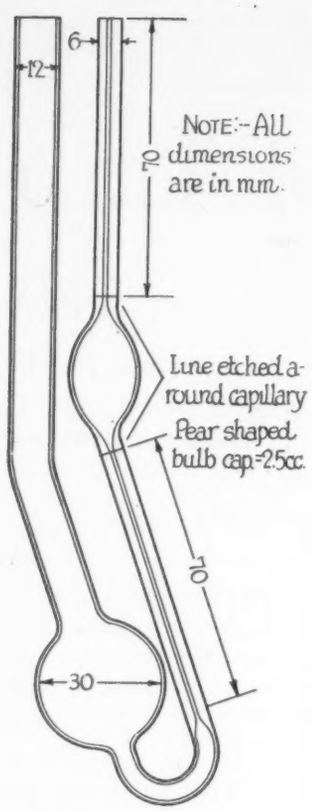
Among the disadvantages are the following:

1. The liquid sample must be strictly free from foreign particles. (Sintered-glass filters have been found very satisfactory for accomplishing this).
2. Each viscometer must be calibrated with one, or preferably more than one, standard liquid.
3. Each viscometer is convenient for liquids of only a fairly definite viscosity range.
4. Results in the desired units are not read directly,



OSTWALD VISCOMETER

FIGURE 1



IMPROVED VISCOMETER PIPETTE

FIGURE 2

but must be obtained by calculation or reference to a table or graph.

In Figure 1 the liquid being tested is permitted to flow slowly by gravity from one bulb to another through the capillary tube. The volume flowing through the capillary is fixed by the capacity of the upper bulb, which is completely filled (by sucking the liquid up into it from the lower bulb, through the capillary) and then the time is taken for the liquid to flow from **A** to **B.** In a properly designed Ostwald viscometer the time of flow is proportional to the viscosity of the liquid, and can be determined very accurately. In an instrument of the Ostwald or Saybolt type the force driving the oil through the capillary is the pressure produced by the column of oil above the outlet; thus the gravity (or density) as well as the viscosity of the oil determines the time of flow. In such a case the time of flow is proportional to the absolute viscosity, *n*, (in centipoises) divided by the density, *d*, (in grams per cubic centimeter). This ratio called the kinematic viscosity, *KV*—the unit being called the stoke, and its hundredth part the centistoke. This unit, while strictly not as useful as absolute viscosity in engineering work, is very convenient; because in instruments of the Saybolt type the time of flow is proportional to the kinematic viscosity, and so the inter-conversion of units is facilitated. Kinematic viscosity is a scientifically precise unit, since multiplying it by the density gives the absolute viscosity: $KVd=n$.

However, as indicated, the Ostwald viscometer needs a general modification to make it most suitable for the measurements of the viscosity of oils. All the features and sources of error were carefully considered, and the best possible solution was incorporated in the final modified design. This modified viscometer is shown in Figure 2. A brief statement of the possible errors follows:

The drainage error involves the problem of the quantity of oil adhering to the upper bulb. The drainage may be made more complete by: 1, making the draining surfaces more nearly vertical; 2, by increasing the time of drainage; and 3, by increasing the volume of the bulb. In addition the drainage error can be further reduced by the method of pipette calibration which is discussed later.

The average head of oil obviously affects the time of flow. Viscometers in which an external applied pressure is used (rather than gravity) to force the oil through the capillary are susceptible to less error.[4] However, this method of operation is not as simple and rapid as using only the force of gravity to effect the flow. The errors regarding the average head of oil can be reduced by minimizing the effect of tilting the apparatus away from a strictly vertical position. Arranging the viscosity pipette as in Figure 2, so that the upper and lower bulbs are always in the same plane, reduces this error to a minimum. A small plumb bob in the wide arm of the pipette easily permits alignment, so that this error is 0.1 percent or less. Second, a variation in the volume of the liquid in the pipette will affect the average head. Errors due to this are reduced by enlarging the lower bulb so that the head is not as much affected by volume of oil in the pipette.

Kinetic-energy and end-correction errors are reduced by a careful correlation of the diameter of the capillary with its length, so that fairly definite sizes of capillary tubes are used for certain viscosity ranges. Also trumpet-shaped openings on the capillary are specified.

The surface tension of the liquid affects the accuracy of the measurements if the upper and lower bulbs are of different diameter. Fortunately, the surface tensions of oils are very much alike; so that if the viscometers are confined to oils, these errors are 0.1 percent or less. It is only when two different liquids, such as oil and water, are measured in these pipettes that the error becomes appreciable (2 to 3 percent). However, in these cases pipettes can be designed to take care of this, by making the average head greater so that capillarity effects are a smaller percentage, and by making the bulbs of more nearly equal diameter.

SPECIFICATIONS FOR VISCOMETERS

In Table 1 are the approximate dimensions that

TABLE 1
Specifications for Three Series of Viscometers

Viscometer series No.	100	200	300
Total volume required, cc....	5.0	5.0	5.0
Volume of upper bulb, cc....	2.5	2.5	2.5
Diameter of lower bulb, cm..	2.5	2.5	2.5
Capillary length, cm.....	7.0	7.0	7.0
Capillary diameter, cm.....	0.07	0.12	0.16
Accurate viscosity range (0.1 percent error):			
Centistokes	4.6-45	40-100	125-1,250
Saybolt seconds 41-200		185-1,800	560-5,500
Useful viscosity range (0.1 to 1.0 percent error):			
Centistokes	1.4-45	4.0-400	12.5-1,250
Saybolt seconds 33-200		39-1,800	68-5,500

determine the construction of pipettes shown in Figure 2. It has been found that three pipettes of the approximate capillary sizes indicated are sufficient to cover the entire range of oils from very light to very heavy. It should be pointed out that these dimensions need not be adhered to exactly, since the pipettes are all calibrated afterward. Five cubic centimeters of oil are used; and by following these specifications approximately, the time of flow for light oils with the 100 series pipettes is of the order of 200 sec., and for the very heavy oils with the 300 series the time is approximately 2,000 sec. Thus, neither is it necessary to sub-divide a second very much for accuracy, or to wait an unusually long time to get a measurement. Stop clocks reading to ¼ sec. are sufficiently accurate, and also very rugged and durable.

CALIBRATION OF THE VISCOMETERS

Re-arranging Poiseuille's law gives:

$$\frac{t}{KV} = \frac{8lV}{3.1416gHr^4} = C$$

where: t is the time in seconds; KV is the kinematic viscosity in stokes; l is the length of the capillary tube; V is the volume of liquid (in cubic centimeters) passing through the tube in time t; g is the gravitational constant (in dynes); H is the average head; and r is the radius of the tube (in centimeters). For a given viscometer, all the terms on the right side of the equation are constant; therefore, the entire expression may be set equal to a constant (C). This calibration constant (C) is evaluated by measuring the time of flow of a standard liquid of known kinematic viscosity (KV_o): $C = \frac{t_o}{KV_o}$. Then, if the viscometer has been so constructed that all the errors can be avoided or corrected for, this calibration constant remains the same regardless of the viscosity of the oil that is being examined; so that the kinematic viscosity (KV) of any oil can be determined by simply observing the time of flow (t) and dividing this by the viscometer constant (C), viz., $KV = \frac{t}{C}$. Even if all the errors have not been reduced to 0, or to an inappreciable extent, such as kinetic energy and end effects, drainage, etc., by using several standard liquids and calibrating over the viscosity range the pipette will be used for, it is possible to calibrate out these remaining errors, since they are all dependent on the time of flow. That is, instead of one calibration constant for a pipette, a calibration curve is obtained. This curve contains the time of flow plotted against the pipette constant as a smooth curve; or if a semi-logarithmic chart is used, a straight line usually results over the proper operating range. Thus, once calibration curves, such as are typified in Figure 3 and 4, are available, and the time of flow of an unknown oil in a particular pipette is known, it is a simple matter to read off the correct pipette constant to use, and divide this into the time to get the kinematic viscosity of the oil. This method of employing a calibration curve for each pipette materially reduces all the errors which may still persist for the errors due to drainage, and kinetic-energy corrections are functions of the time of flow.

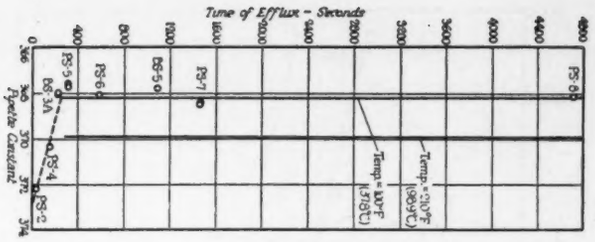


FIGURE 3
Calibration Curve for Viscometer No. 220.

In case exactly 5 cm. of oil were not placed in the pipette, it is a simple matter to correct for this by means of Figure 5, which allows for the additional volume affecting the average head of oil in the pipette. Also it has been found necessary to calibrate only at 100 deg. F., and to calculate the corresponding calibration curve for other temperatures (130 deg. F. or 210 deg. F.) from the change in density of the oil as affecting the volume in the pipette. Figure 5 also permits these changes to be made readily.

Before the pipettes are used, they must be absolutely clean and dry. Instruments received from the glass blower were washed with water, and allowed to stand when filled with chromic-acid cleaning solution. After cleaning solution had been washed out, they were rinsed with distilled water, and dried. Between measurements on oils they are washed with filtered, dust-free petroleum ether, or benzene and acetone, and dried.

Oil samples must be free from dust. If there is any doubt as to the probable presence of dust, the sample should be filtered through a sintered-glass filter. The oil sample is measured with a standard 5-cc. delivery pipette. The pipette is inserted as far down into the wide arm of the viscometer as possible. Care should be taken to get no oil on the up-

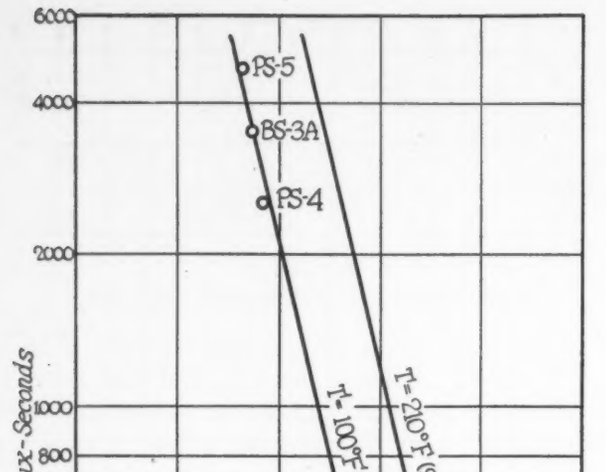


FIGURE 4
Logarithmic Calibration Curves for Viscometer No. 104.

per part of the tube where it might come in contact with the plumb bob. In order to get the full 5-cc. delivery of the pipette, it and the viscometer are placed in an oven at 215 deg. F., and allowed to drain. Experiments demonstrated that this procedure is perfectly reliable. For more accurate work, the oil is weighed into the viscometer.

The pipettes are contained in transparent thermostated baths, such as a Pyrex glass jar. A slit rubber stopper around the two arms makes a convenient support. The stopper can fit into a plate lying on the top of the bath, and with plumb bob the stopper is easily adjusted to get the viscometer vertically aligned.

STANDARD VISCOSITY LIQUIDS

The U. S. Bureau of Standards has oils of various absolute or relative viscosities known to approximately 1 percent. In the course of this work especially standardized oils were made and used. Since the pipettes only require 5 cc. of oil, and breakage is not serious, 2-gal. samples of standard oils last a long time, or serve to calibrate a large number of pipettes. These standard oils were made from fractions of petroleum oils having the desired viscosity ranging from 0.0217 to 12.80 stokes (34 to 6,400 Saybolt sec.) at 100 deg. F. Prior to standardization, the fractions were treated with anhydrous aluminum chloride, the sludge separated, the oil washed, and then filtered through activated charcoal. Standardization was accomplished by means of a Washburn precision viscometer[5] made of quartz.* Accurate viscometer constants for this master pipette were obtained by using distilled water at various rates of shear. A value of 1.005 centipoises (1.008 centistokes) was used for the viscosity of water at the calibrating temperature of 20 deg. C. (68 deg. F.). U. S. Bureau of Standards oils were also used to get independent checks on the calibration of the pipettes.

USEFULNESS

During the last two years some 100 viscometers of this design have been used by approximately 20 research workers for measurements at 100 deg. F. (37.8 deg. C.), 130 deg. F. (54.4 deg. C.), and 210 deg. F. (98.9 deg. C.). The various research workers using different viscometers check viscosities to within 0.2 percent. The time required for a determination is not excessive, it being possible in some cases to average 40 viscosities per day, and check the time of flow in the same pipette at least twice.

VISCOSITY MEASUREMENTS AT LOW TEMPERATURES

Viscosity data at low temperatures, viz., 32 deg. F. and below, are useful, not only for studying the flow of oil, but also in a variety of problems pertaining to wax, its effect on viscosity, and the action of sub-

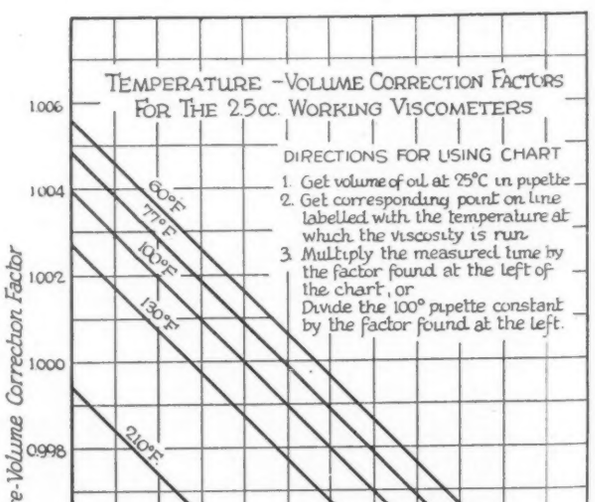


FIGURE 5

stances which inhibit or affect wax crystallization. Pipettes of the design shown in Figure 6 have been found very suitable for this work. Since the viscosity is very high at low temperatures and drainage errors are serious, the pipette is operated as a pressure viscometer. That is, pressure is applied to the wider arm, and the time of flow is measured for the oil to rise in the lowest pear-shaped bulb (bulb 1), this bulb at the start being free from oil. If other measurements are needed, such as after partially destroying the wax structure by working the oil or for any other reason, there is available another clean bulb, the middle one (bulb 2), and still another (bulb 3) at the top. Thus, the maximum amount of data can be obtained without handling the pipette or recooling the oil. In problems involving wax, the rate of cooling affects the viscosity of the waxy oil; and with pipettes of this design it is easy to standardize on cooling rates and obtain reproducible viscosity measurements. In other cases it is important to observe the viscosity effects produced by working or shearing the oil by forcing it back and forth through the capillary and then using a clean bulb to measure its viscosity or apparent viscosity.

Each of the three bulbs is calibrated with standard viscosity oils at some convenient temperature, say 100 deg. F., prior to use. For the case of a pressure viscometer the pipette constant, C, is:

$$C = \frac{(H-h)t}{KV}$$

where: H is the height of a column of oil in centimeters corresponding to the pressure used; h is the oil head in the pipette in centimeters; KV the kinematic viscosity; and t the time of flow in seconds. In order to evaluate this constant, the average head of oil for each bulb needs to be known. This can be easily determined by using the ordinary pipette constant, C_o, where no pressure is applied; i.e., the oil flows under its own head, as in the case of the modified Ostwald pipettes described above. The value of h is given by:

$$h = \frac{Ht}{C_oKV+t}$$

H is measured in centimeters by an external manometer containing oil or water, and converted to correspond to the equivalent head of oil at the temperature of the pipette. By the equation above for C, it should be really a constant independent of pressure and time. Experimentally, this is found to be true.

A convenient bath for containing the pipettes is a glass jar well insulated, except for openings for viewing the pipettes. With no other means of refrigeration available and a bath of 5- to 10-gal. capacity, temperatures down to 0 or 10 deg. can be satisfactorily maintained by adding ice and salt to the water in the bath. By this means, with a well insulated bath, it is possible to hold temperatures constant to ± 0.5 deg. F. for several hours. A satisfactory low-temperature thermostat is obtained by using a small Frigidaire unit, and immersing the

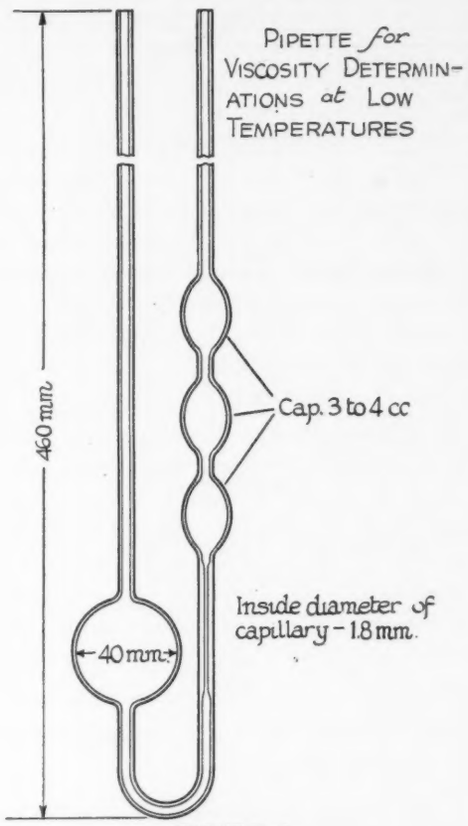


FIGURE 6

cooling coils in a stirred-kerosene or water-glycol bath. By regulating the expansion valve, various rates of cooling are attained; and by leaving the valve set so that the bath tends to be always colder than the desired temperature, and then installing an electric heater and mercury thermoregulator, temperature control of the order of 0.1 deg. F. is attained.

Typical results on two Pennsylvania oils by closely matched 210 deg. F. viscosity, but of different pour points, 0 deg. F. and 30 deg. F., are shown in Figure 7 and 8. The inspection data on these oils are in Table 2.

As seen, the higher-pour-point oil at 10 deg. F. is not behaving as a true fluid, since its viscosity is dependent on the rate of shear. The lower-pour-point oil, since no wax has separated, is still following the laws of viscous flow. Data of this sort are much more useful than measurements of pour point.

It is interesting to compare the value of the kinematic viscosity of oil **B** at 10 deg. F., which was found to be 52 stokes (approximately 26,000 Saybolt sec.) with that obtained from an A.S.T.M. chart by extrapolating from the 100 deg. F. and 210 deg. F. viscosities. The extra-polated kinematic viscosity is about 58 stokes (approximately 29,000 Saybolt sec.)

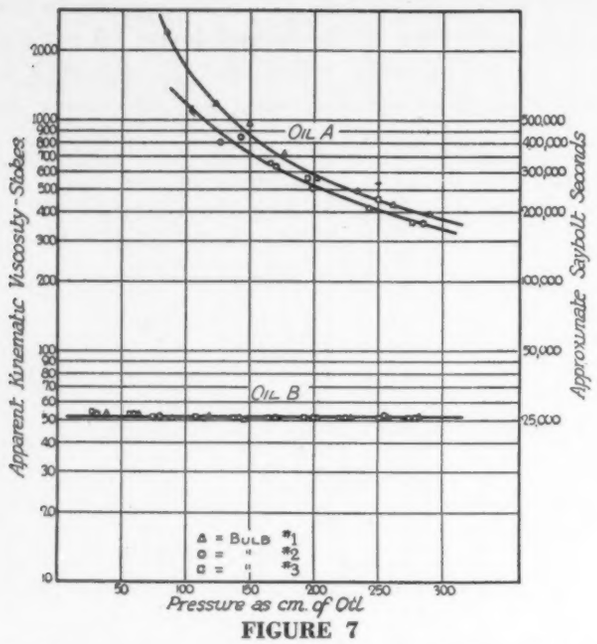


FIGURE 7

The Apparent Kinematic Viscosity of Oils at 20 Deg. F. Cooling Rate = 60 Deg. F. Per Hour.

Oil	Saybolt Seconds: 210 Deg. F. Viscosity at	Saybolt Seconds: 100 Deg. F. Viscosity at	Deg. F. Pour Point,
A	61.1	426	30
B	61.6	465	0

it not being possible to extrapolate more accurately than to about 2 stokes.

THE CONVERSION OF KINEMATIC VISCOSITY TO SAYBOLT SECONDS

Since the Saybolt viscometer is in universal use in this country, and it serves for control work, manufacturing processes and the buying and selling of oil,

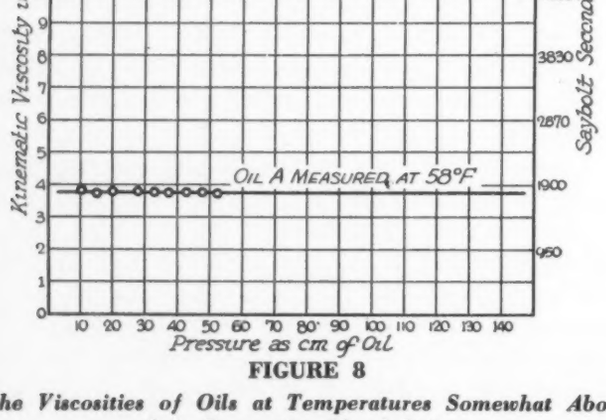


FIGURE 8

The Viscosities of Oils at Temperatures Somewhat Above their Respective Cloud Points.

Oil	Saybolt Seconds: Viscosity at 210 Deg. F.	Saybolt Seconds: Viscosity at 100 Deg. F.	Pour Point, Deg. F.
A	61.1	426	30
B	61.6	465	0

TABLE 2

Inspection Data on Oils

	Oil A	Oil B
Viscosity at 210 deg. F.:		
1. Kinematic (stokes)	0.1044	0.1058
2. Saybolt seconds	61.1	61.6
Viscosity at 100 deg. F.:		
1. Kinematic (stokes)	0.9059	0.9884
2. Saybolt seconds	426	465
Gravity, deg. A.P.I.	29.4	28.0
Specific gravity at 10 deg. F.	0.8973	0.9053
Flash point, deg. F.	425	440
Fire point, deg. F.	485	505
Pour point, deg. F.	30	0
Cloud point, deg. F.	32	2

it is not to be expected that a different unit of viscosity can be introduced, any more than it would be possible to change this country from the English system of units to the metric system. On the other hand, research and engineering work should not be expected to contend with a unit not intended in any way for such purposes. Since the research and engineering groups should possess the most accurate methods based on fundamental concepts in order to insure the security of their work and the greatest application of it to other fields, the most logical basis would be to have the Saybolt viscosity scale defined by an equation or certain fundamental data containing a fundamental unit of viscosity, instead of having it defined in terms of a master tube kept at the U. S. Bureau of Standards. Then the research and engineering groups should always be correct, since they will be working in fundamental viscosity units; and the control, manufacturing, and marketing groups could still have the widely-known Saybolt viscosity basis to facilitate their work. If matters of greater accuracy or controversy arose, the problem would be turned over to the scientific group—where it naturally belongs.

This condition does not exist at present. A Saybolt second is defined by the master tube at the U. S. Bureau of Standards. There is no definite universally-accepted relationship between this unit and more precise methods for viscosity measurement. There are several existing conversion equations, but they agree only to within approximately four percent.

Approximately 100 oils were selected for measurement of the kinematic and Saybolt viscostiy at 100 deg. F. and at 210 deg. F. The oils were from various sources, and represent a variety of typical crudes. The viscosity range studied included Saybolt seconds from 34 to 6049, with viscosity indexes from —17 to 113. The viscosity of 43 of the oils was measured at 210 deg. F., and the range of viscosity at 210 deg. F. was from 37 to 678 Saybolt seconds. Fortunately, the points for 210 deg. F. fall on the same curve as the points for 100 deg. F. These data will be presented at a later time when the best A.S.T.M.

procedure for Saybolt viscosity measurements is established.

THE PROBLEM OF THE VISCOSITY INDEX OF LIGHT OILS

The Saybolt viscometer as used in ordinary routine work is hardly precise enough to measure the Dean and Davis[7] viscosity index of light oils. This is because the differences in the viscosities of the 0 and 100 viscosity-index oils is quite small for light oils. For the case of Pennsylvania oils, an error of 0.5 sec. in the 210 deg. F. viscosity of an oil measuring 40 Saybolt seconds results in an error of about 14 points in viscosity index. The greater the time error and the lighter the oil, the greater the error in viscosity index. While it is true that the value of viscosity index is not as great in the case of light oils as it is for heavier oils, the problem of the viscosity-temperature coefficient for light oils still exists. Well refined oils of viscosities as high as 60 sec. at 210 deg. F. may contain 20 to 30 or more percent of oils below 45 sec. at 210 deg. F. Since lighter oils have become increasingly popular for winter use, there are many practical problems involving viscosity data other than those relating to the identification of oils. In addition, problems involving improvements in oils naturally involve light oils; since these are, in general, more readily processed than heavier ones.

In the course of research work on light oils, statements are heard about exceptionally high viscosity indexes. For the most part the trouble is in the inaccuracies of the Saybolt viscometer, where a small time error produces a large shift in viscosity index. However, it is in general true that light oils can be made to have higher viscosity indexes than heavier oils. This is due again to the method upon which viscosity index is based. Figure 9 shows the limiting Dean and Davis[7] viscosity index of oils as a function of the viscosity at 210 deg. F.; i.e., the curve represents oils which have the same viscosity at 100 deg. F. as at 210 deg. F. Obviously, these are hypothetical materials. If the difference between the curve and the abscissa is divided uniformly, it has been found that this furnishes a convenient basis for rating the changes produced in oils by solvent extraction for oils above 100 viscosity index; i.e., the oils are compared on the basis of the percentage of the total improvement possible.

It has been stated that the viscosity index of lubricating fractions produced by conventional methods from any given crude is approximately constant. In the course of a study of the properties of lubricating fractions from various crudes, a variety of oils were carefully fractionated in a high-vacuum fractionating column charging 5 gal. of oil, and operating at below 1 mm. pressure. Fractions which are 4 to 5 percent of the charge and have a spread of 15 deg. to 25 deg. F. on a vacuum Engler distillation at 10 mm. pressure between the initial and the 90-percent points, are found to vary in viscosity index from 10 to 50 or more points. The various fractions of Pennsylvania oils are quiet constant, and they should be, since these form the basis of the 100 viscosity-index oils.

TABLE 3
Viscosity Characteristics of Light Pennsylvania Oils

Viscosity at 210° F. (Centistokes)	Viscosity at 100° F. (Centistokes)
3.40	16.50
3.60	18.15
3.80	19.80
4.00	21.50
4.20	23.30
4.40	25.05
4.60	26.90
4.80	28.80
5.00	30.65
5.20	32.55
5.40	34.50
5.60	36.50
5.80	38.60
6.00	40.75
6.20	43.00
6.40	45.25
6.60	47.55
6.80	49.80
7.00	52.00
7.20	54.25
7.40	56.45
7.60	58.70
7.80	60.90
8.00	63.15
8.20	65.35
8.40	67.55
8.60	69.75
8.80	72.00

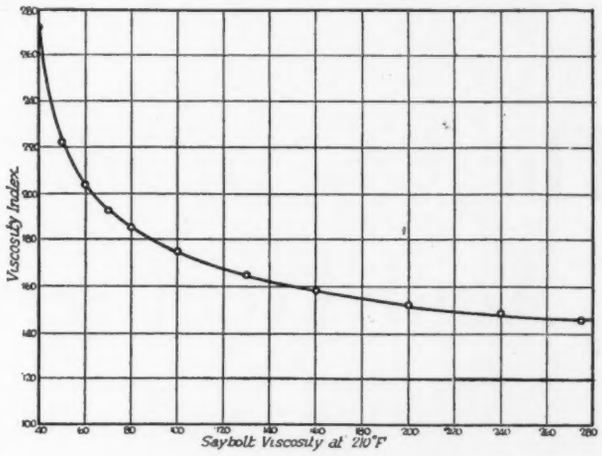


FIGURE 9
Maximum Theoretical Viscosity Index as a Function of Saybolt Viscosity at 210 Deg. F.

In the range of light oils there are no very accurate data on the temperature-viscosity characteristics of oils of 100 viscosity index. Because of the errors easily introduced, the viscosities should be measured in some form of capillary viscometer; and, accordingly, should be available in kinematic as well as Saybolt units. In order that more accurate data may be available, the 100 deg. F. and 210 deg. F. viscosities of about 100 closely fractionated and commercial grades of Pennsylvania oils ranging from 38

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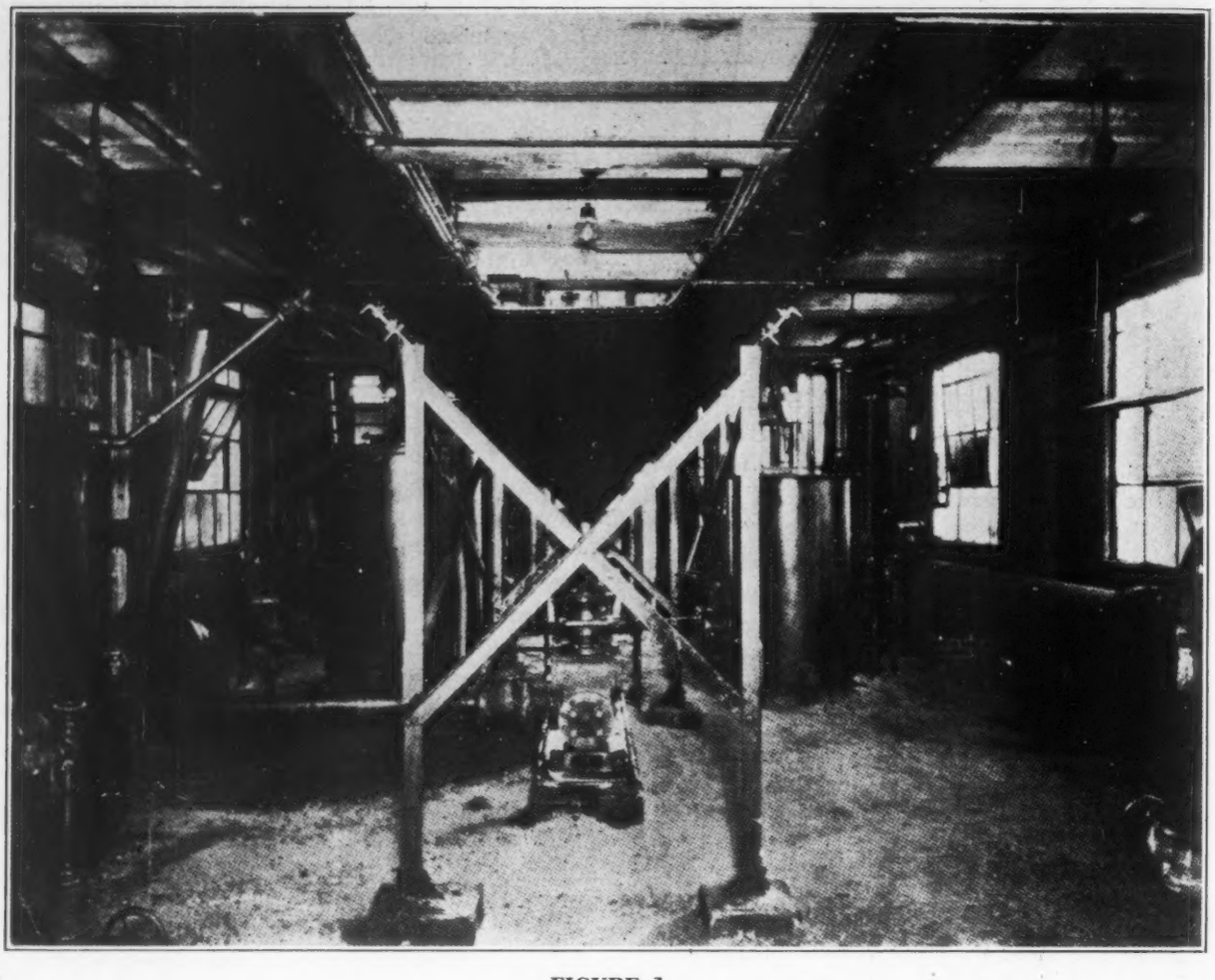

FIGURE 1

The Use of the Centrifuge in Acid Treating Petroleum Stocks

LEO D. JONES

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IT has been common practice for at least half a century to purify petroleum lubricating oils for the purpose of improving color and stability by treatment with sulfuric acid. The conventional method of carrying out this operation has varied very little, and consisted of agitating the acid with the oil to be treated by air blowing, allowing the sludge formed to settle by gravity, and separately withdrawing the settled sludge and the treated or sour oil.

In the operation of this conventional process the separation of the sludge by gravity separation is frequently not all that is to be desired either from the standpoint of completeness of separation or time required for the separation. Accordingly, it is not strange that many proposals have been made in the past for substituting centrifugal force for gravity, and that considerable experimental work has been done. Because the available centrifugal separating equipment was not suitable, the early attempts to separate the complete mixtures of sludge and oil were universally unsuccessful. Continuous discharge of the sludge was prevented by clogging of the centrifugal rotors, and suitable equipment for feeding a uniform mixture to the centrifuge was not available.

On account of the difficulty of discharging sludge, attempts were made to centrifuge gravity-settled sour oil for the removal of pepper sludge which would not settle by gravity. While such a procedure was apparently successful, the advantages gained by

THE centrifugal process for acid treating lubricating oils consists in proportionately and continuously measuring oil and acid, mixing them mechaniaction and then continuously separating the sludge and sour oil with a super-centrifuge. Lubricating oils of all viscosities, both naphthenic and paraffinic, may be treated by this process with a very substantial recally for a short period of time to cause their reduction in loss of oil to sludge and a reduction in the acid required. Photographs of commercial plants in operation are shown and described.

Paper presented at Fourth Mid-Year Meeting, American Petroleum Institute, at Pittsburgh, Pennsylvania, May 23, 1934.

having a slightly cleaner sour oil did not justify the cost of the operation.

Concentrated research work and development of equipment over recent years has resulted in eliminating the difficulties which caused the failure of early attempts, so that there are now in operation a number of commercial installations which are continuously treating and centrifugally separating sludge from cylinder stocks and other oils.

CENTRIFUGE NOW USED FOR ACID TREATING

Figures 1 and 2 photographs of one of these installations which is treating 1000 barrels of cylinder stock per day.

The equipment used in this installation is shown diagramatically in Figures 3 and 4. The raw oil from tank storage outside of the building flows to either of the raw oil pumps shown in Figure 3. From one of these pumps it passes to the heater, where the temperature is raised to the required value for treating. It then passes to the proportionometer, where the flow of oil is measured, and then on to the mixers. The raw-oil pumps are behind the tank in the far right side of Figure 1, and the heater is along the right wall of Figure 1. Tre proportionometers and mixers are on the second floor of the building along with the super-centrifuges, and are arranged in a line behind the super-centrifuges, and parts of the proportionometer are just visible in the extreme right and left of Figure 2.

An acid supply tank is situated on the second floor. Acid is pumped to this supply tank with an overflow return. The acid flows from the acid supply to the proportionometer, where it is measured; and then to the mixers, where it comes in contact with the oil. In this installation two mixers are used in series, and the reaction is completed by the time the mixture leaves the second mixer.

The mixture flows through a header and

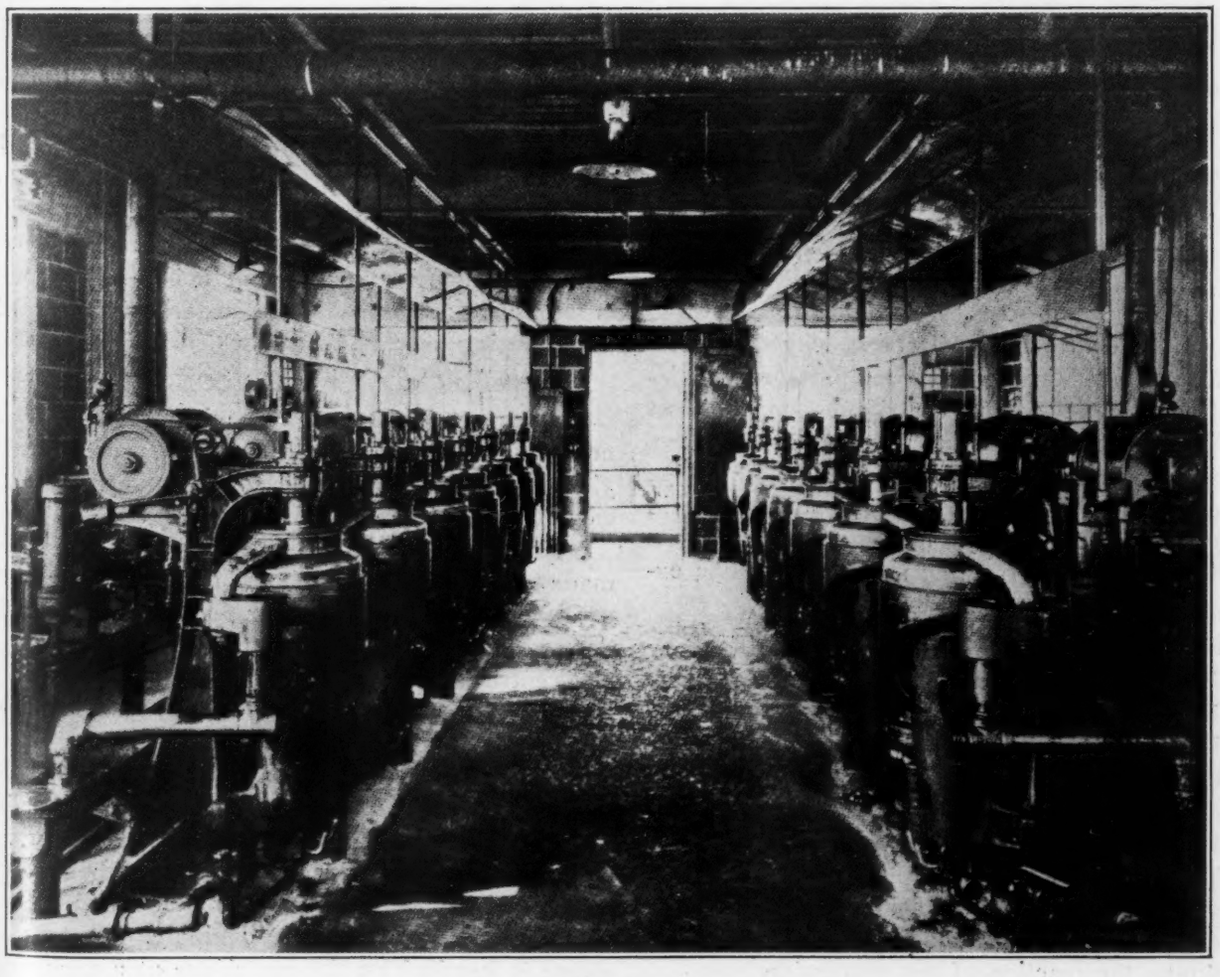

FIGURE 2

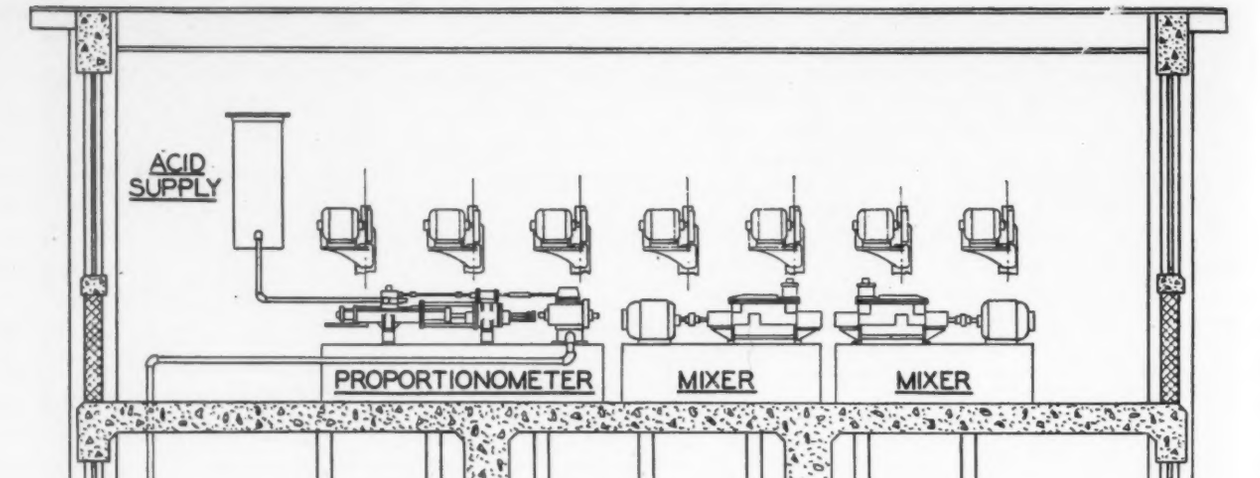

FIGURE 3

through branches to each of the super-centrifuges.

The super-centrifuges continuously discharge sludge-free sour oil into troughs behind the super-centrifuges from which the sour oil flows to the receiving tanks on the first floor of the building. The two receiving tanks are visible at the far end of Figure 1. From these tanks the sour oil is pumped to storage outside of the building.

The sludge continuously discharged by the super-centrifuges flows through vertical pipes to the V-shaped hopper below the centrifuges on the first floor, from which it is pumped by magma pump to a sludge-treating system outside of the building. The V-shaped hopper is the most conspicuous object in Figure 1, with the sludge pump immediately below it; and the sludge discharge line is the 4-inch line extending left from the magma pump.

PROCESS BOTH SIMPLE AND REFINED

While all of the equipment used in these installations is comparatively simple and rugged in construction, there is considerable refinement in the coordination of the various units.

The oil and acid must be measured proportionately at a rate depending upon the unit rate and the number of centrifuges which are in operation; and since the elapsed time between the contact of the acid and oil and the separation of the sludge is of the order of one minute, the reaction of the proportionometer to changes of flow must be very prompt, automatic, and accurate over a wide range of throughput. It must, in the installation described above, be capable of giving accurate proportions when only one, or seven, or any intermediate number of the battery of centrifuges is in operation. The successful development of a proportionometer meeting the above requirements is largely responsible for the cussess of the centrifugal treating process.

DESIGN OF MIXERS HAS ECONOMIC VALUE

Refinement of the design of mixers is vitally connected with the economic value of the process, as the yield as well as the quality of the final product is closely connected with mixing conditions.

New refinements in the super-centrifuge have been made to allow for the discharge from the rotor of the extremely viscous stock separated from heavy cylinder stock, and also to carry this sludge away from the centrifuge to a collecting hopper. The centrifuges are vapor-tight, eliminating any leakage of sulfur-dioxide fumes. The centrifuges are commonly cleaned every 48 hours as a matter of routine, but have been run for as long as six days without difficulty due to sludge clogging or dirt accumulating. A somewhat different super-centrifuge has been developed for the separation of acid and sludge in the continuous treating of pressure distillate. Pressure distillate is handled by the centrifuge at a very much

higher rate of flow, because of its low viscosity, than cylinder stock—each centrifuge handling 40 barrels of pressure distillate per hour; whereas the sludge is quite fluid, and in small quantities.

Returning to the treating of lubricating oils, the mixture of sludge and oil as it leaves the mixer is quite viscous, with a tendency to solidify on cooling or standing in any portion of the pipe lines conducting the mixture to the super-centrifuge. Special header designs and valves for the branch lines to the centrifuges have been developed which eliminate the difficulties at first encountered, and are vital to a satisfactory operation of the process.

The outstanding merit of the use of centrifuges in the acid treating of lubricating oils is the reduction in the loss of treated oil to sludge as a result of a more complete separation under centrifugal force than is obtainable by gravity. Depending upon the oil, the loss to sludge is reduced by from 30 percent to 50 percent. A cylinder stock, for instance, which by the conventional method of acid treating shows a loss of 33 percent will lose only 23 percent when treated by the centrifugal process. On another cylinder stock, with a loss of 42 percent by the conventional method, the centrifugal process gave a loss of 28 percent. A naphthenic distillate with a viscosity of 600 sec. at 100 deg. F. lost six percent when treated with 12 pounds per barrel of acid, and the loss by the centrifugal method was three percent.

LOSS SMALLER WITH CENTRIFUGAL PROCESS

The process has been operated on cylinder stocks with viscosities as high as 360 sec. at 210 deg. F., which oils cannot be treated by the conventional method except by diluting with naphtha or treating as a long residue, and then topping after treating. A number of refiners are now acid treating cylinder stock in dilution in naphtha. A very considerable loss of naphtha accurs to the sludge in such procedure. These same stocks can be treated by the centrifugal process without the use of naphtha—thus saving all of the naphtha loss, and the loss of oil is also reduced. As a specific example, a stock was treated in dilution using 30 percent of naphtha and 70 percent of oil, by the conventional treating method. Using gravity separation, the loss of oil was 26 percent of the oil treated, and the loss of naphtha was seven percent on the basis of the oil treated. This same oil was treated by the centrifugal process with a loss of only 24 percent of oil, and with no loss of naphtha.

Oils ranging in viscosity from 50 sec. at 100 deg. F. to 360 sec. at 210 deg. F., both paraffinic and naphthenic, have been treated by the centrifgual process —all with reduction in loss figures within the range given above.

ACID SAVINGS OF PROCESS NOT CONSISTENT

The saving in acid used in treating by using the centrifugal treating process is not very consistent. In treating heavy naphthenic oils equal quality of products has been obtained using eight pounds of acid per barrel by the centrifugal method, as compared with 12 pounds per barrel by the conventional method. In some unusual cases greater savings than this have been obtained. On the other hand, the paraffinic oils—especially those containing little asphalt — require substantially the same amount of acid for treatment by either process.

The process may be operated using 66 deg. Beaume acid, 98 percent acid, or even fuming acid if it is desired; and where excessively high treats are made in multi-stage, the equipment is suitable for re-treating sour oil.

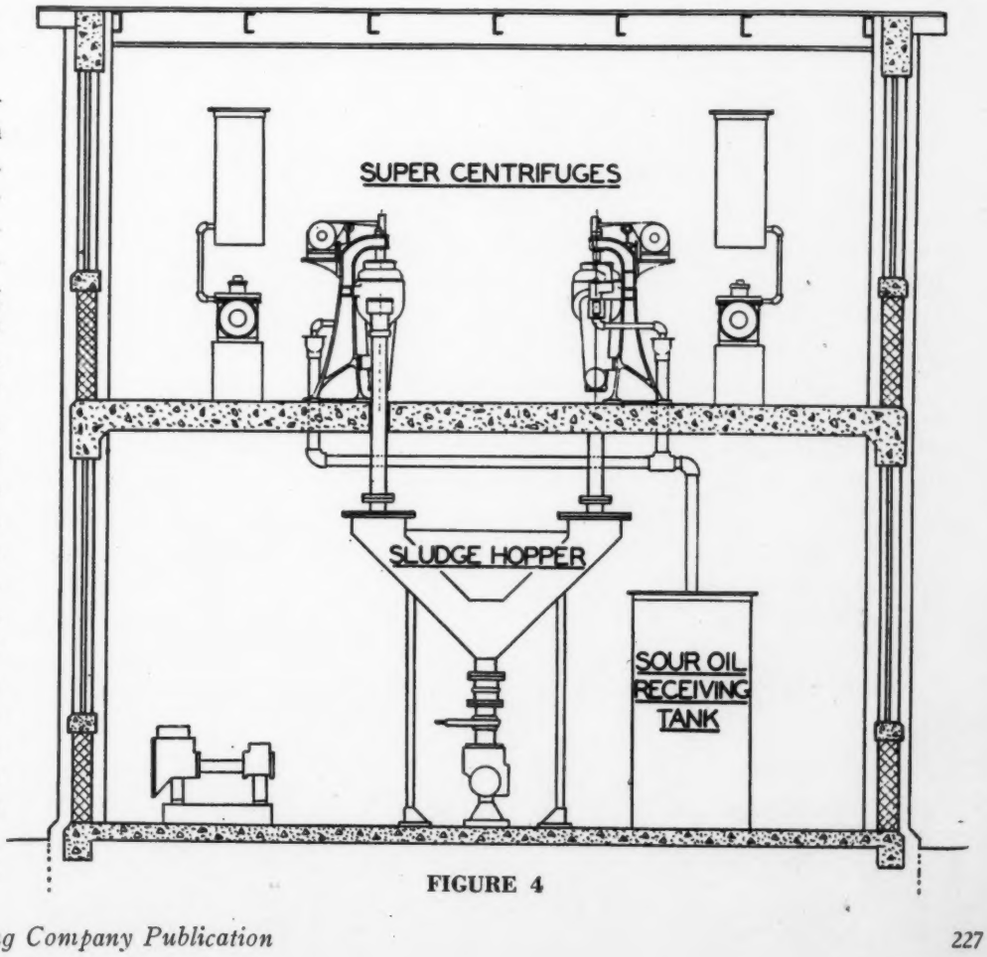

FIGURE 4

Continuous Treating of Oils With Centrifugal Separation

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THE continuous acid treatment of lubricating-oil stocks has been made feasible by the development of highly specialized centrifugal separators and by properly designed auxiliary equipment, the object of which not only is to effect the proper treatment of the oil, but to put it in such condition that the acid sludge can be most effectively removed by the centrifuges. Work has been completed on the acid treatment of practically the entire range of oils from pressure distillates to heavy overhead and residual cylinder stocks.

As compared with treatment in the conventional type of batch agitator, the continuous method effects marked economies in the amount of acid used, in the amount of earth or neutralizing agents, and in the reduction of refining losses. The centrifugally-separated sludge is less viscous than that obtained in batch treatment with air blowing, and can be disposed of with greater facility. In addition, the continuous acid-treating plant is inherently more flexible in operation.

Paper Presented at Fourth Mid-Year Meeting, American Petroleum Institute, at Pittsburgh, Pa., May 23, 1934.

ANY attempt to review completely the history of the use of sulfuric acid as a refining agent for hydrocarbons would date back over the last century to 1792, when acid was first employed in England for improving color and odor of coal oils. The reference gives a description of the process which, briefly, consisted of adding the acid and "violently agitating the oil with a bellows." It is significant that the same method is used today, with very little deviation from the original procedure.

In the United States Patent Office references can be traced back to 1852, when Patent 8883 was issued to J. Young, who claimed the treatment of oil distillates with sulfuric acid. From this time on the number of patents issued on acid treatment increased rapidly, covering as well the treatment and recovery of the numerous by-products from the sludge. The disposal of the sludge in a facile and economical manner is still a problem facing the refiner today in spite of the several hundred patents which have been issued on the subject. The skeleton in the closet of almost every refinery is that portion of the yard where at some time acid sludge has been dumped or buried.

BATCH AGITATOR THE CONVENTIONAL ACID TREATER

There are few refineries in operation today which do not use the conventional batch agitator in the acid treatment of oils. In recent years there has been a trend towards continuous treatment, especially in the case of light oils. This change has resulted in lower operating costs, in a reduction in the fire hazard ever present in the blowing of gasoline, and in a more efficient utilization of chemicals. In the treatment of lubricating stocks, however, the industry has clung tenaciously to the use of the batch agitator—suffering high maintenance, inefficient use of chemicals, inflexible operations, and the difficult disposal of a hard, viscous sludge.

CENTRIFUGAL SEPARATORS STUDIED

A thorough study has been completed covering the application of centrifugal separators to the continuous acid treatment of petroleum products—based on experimental work dating back about eight years, followed by the installation of commercial units in refineries which are operating satisfactorily at the present, and showing a substantial saving over batch treatment with gravity separation. This study includes practically all oils produced in the refinery, starting with light oils (pressure distillate and kerosene) and including paraffin distillate, side-cut lubricating fractions of higher viscosities, and overhead and residual cylinder stocks.

Due to the limited scope of this paper, only a few of the results obtained in actual plant operation can be mentioned. No attempt will be made to discuss the chemical aspects of acid treatment, as it is realized that the subject is complex and not entirely agreed upon even by the best authorities. This phase of the work is willingly left to the oil technologists, and this paper will deal only with the presentation of such physical factors as oil loss; characteristics of the sludge produced; color, gravity, and acidity of

the treated oil; and improvements in the economy of acid treatment and subsequent finishing steps.

CENTRIFUGAL SEPARATORS REMOVE SLUDGE

The continuous acid treatment of lubricating oil stocks has been made feasible by the development of highly specialized centrifugal separators which are designed to effect rapid and complete removal of the sludge from the treated stock, in place of the conventional gravity settling of the batch method. But of almost equal importance has been the development of properly designed auxiliary equipment to effect the proper treatment of the oil and at the same time to put the oil in such condition that the sludge can be most efficiently removed by the centrifugal separator. The equipment used is shown diagrammatically in Figure 1.

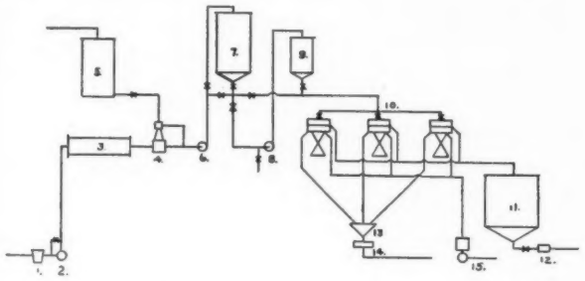

FIGURE 1

Flow Diagram of Continuous Acid-Treating Plant.

OPERATING SEQUENCE DESCRIBED

The continuous treatment is analogous to the procedure employed in batch treatment—even to the well-known "sousing" or addition of water to agglomerate the sludge. While this step is indicated in the flow diagram, its use is optional—being dependent upon the characteristics of the oil treated. Greatly improved results have been obtained in certain instances by the use of this "sousing" step, which accomplished a reduction in the residual acidity of the treated oil and caused a gathering of the sludge, thereby increasing the operating throughput of the centrifuges.

The operating sequence is as follows: The oil is pumped from the raw-oil tank at machine capacity through the tubular steam heater (or tank) and through the proportioning device which maintains the flow of acid into the oil at a predetermined rate. From the proportioning device the mixture passes to the mixing pump, where the acid is thoroughly dispersed in the raw oil. This mixing pump discharges into a reaction tank—preferably a closed vessel—where the volume is regulated to achieve the optimum reaction time. From the reaction tank the mixture of oil and sludge may be passed through the "sousing" mixing pump—where water is added for the aforementioned purposes—and then through a second smaller reaction tank; or it may be sent direct to the centrifugal separators. Each centrifuge discharges three components, viz., the sludge-free treated oil, the heavy viscous acid sludge, and free acid.

The important points of control affecting the operation are:

1. Quantity of acid.
2. Treating temperature.
3. Degree of mixing.
4. Reaction time.
5. Degree of separation.

Of these the first two are maintained automatically by conventional control devices. The mixing pump is especially designed to give the proper degree of mixing and agitation. The reaction time may vary from a few seconds up to several minutes—seldom exceeding 10—and is dependent upon the nature of the oil being treated and, to some extent, upon the degree of agitation in the mixing pump.

In operation the degree of separation is tested occasionally, small samples of the acid oil being taken and subjected to a very high centrifugal force in a small test machine—the whole operation taking about 10 minutes to be completed. With this high-speed test-tube centrifuge it is possible to measure quantities of sludge or acid remaining in the oil as small as 0.01 percent. This unit is of considerable importance from a control standpoint, as it indicates definitely and quickly what results are being obtained. After the system has been adjusted to a single set of conditions, no further attention is required except periodic inspections.

Discharge of the sludge and weak acid is at all times accomplished continuously, so that there is no necessity of stopping the machines for bowl cleaning. Frequent examinations of bowls in service have failed to reveal any accumulation of the semi-solid, non-plastic material, asphaltic in nature, sometimes encountered in similar operations. Collecting hoppers on the separators are so designed as to facilitate the flow of sludge so that no backing up of the material is experienced. The machines are shut down for inspection at intervals of a week or so.

In Figure 2 is shown a cross-section of the acid-sludge separator bowl, the design of which is the result of extensive laboratory and field work. A special feature of this bowl is the acid nozzles located near the bottom of the bowl which provide for the continuous discharge of free acid. It has been determined that when treating most oils three components are encountered, viz., oil, sludge, and free acid; and, as these three components divide into three layers, it is necessary to provide for the discharge of each.

In a centrifugal separator bowl of conventional type means are provided for the discharge of two

components, and the presence of a third of different specific gravity would upset the operating stability of the centrifuge. In the type of acid-sludge bowl illustrated any accumulation of free acid is discharged continuously through the acid nozzles; and this type of bowl is, therefore, inherently stable. Once the proper adjustment of discharge-ring size has been made, no further attention is required—and even material fluctuations in throughput rate and quantity of acid will not upset the operating balance.

At the end of a run, when the centrifuge is stopped, the contents drain from the bowl into the casing; and the machine is again run up to speed, which

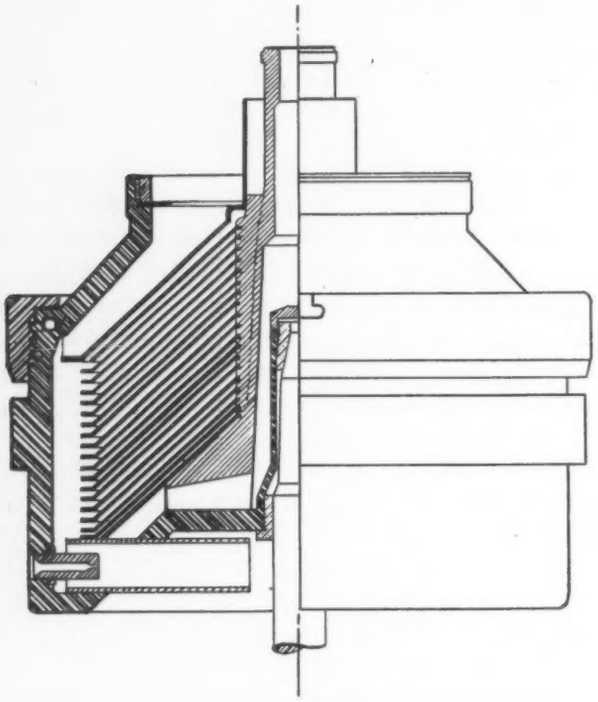

FIGURE 2

Cross-section of Acid-Sludge Type Separator Bowl Used in Treatment of Lubricating-Oil Stocks.

serves to clean thoroughly the discs in the bowl. The machine is again stopped, and the cleaned discs are removed as a unit—the bowl being then submerged in an alkaline solution which, if the unit is to be shut down for any length of time, is followed by a benzol-alcohol wash. For running continuously, or even for overnight shut-downs, no cleaning is necessary.

CONTINUOUS ACID TREATMENT ECONOMICAL

The continuous acid treatment of lubricating oils, with centrifugal separation, has resulted in marked operating economies. Acid requirements are materially reduced. Due to the more complete separation of the sludge, refining losses are lowered, and the reduced acidity of the separated oil results in further economies in the neutralizing and finishing operations.

As examples of direct comparisons between conventional batch and continuous treatment the following data are submitted:

CHARACTERISTICS OF STOCK TREATED
Paraffin Distillate from East-Texas Crude

Gravity, deg. A.P.I.	29.5
Viscosity at 100 deg. F., Saybolt seconds	75
Pour point, deg. F.	75/80
* Color, A.S.T.M. No.	3

* Original color at still, 2¼ A.S.T.M., darkened to 3 A.S.T.M. by heating during transfer.

The batch-treating cycle was as follows:

	Time (Hrs.)
Charging agitator, 2000 bbl.	4
Addition of first acid (1½ lb. per 50 gal.)	½
Blow period	½
Settling period	12
Drawing first sludge	1
Addition of second acid (4½ lb. per 50 gal.)	½
Blow period	½
Sousing water	½
Blow period	½
Settling period	3
Drawing sludge	1
Transfer period	4
Total cycle	28

The continuous treatment was carried out at a throughput rate of 600 gallons per hour per machine, with the following results:

	Batch	Continuous	
Quantity of acid, lb. 66-deg.-Beaume per 50 gal.	6	6	4
Tests on acid oil:			
Gravity, deg. A.P.I.	29.9	29.9	29.9
Viscosity at 100 deg. F., Saybolt seconds	73	73	73
Color, A.S.T.M. No.	2¼	1½	2¼
Acidity, mg. potassium hydroxide per gram	1.1	0.62	0.30
Appearance	Heavy traces of sludge	Microscopically free of sludge at 300 diameters	
Tests on sweetened oil (3-deg.-Beaume lye solution used):			
Gravity, deg. A.P.I.	29.9	29.9	29.9
Viscosity at 100 deg. F., Saybolt seconds	73	73	73
Color, A.S.T.M. No.	2 dark	1½	2
Neutralization No., mg. potassium hydroxide per gram	0.06	0.01	0.01
Color stability (24 hours at 210 deg. F.)	Poor	Good	Good

SLUDGE CHARACTERISTICS

	Batch	Continuous	
Oil loss, percent of charge	1.7	1.1	0.73
Sulfuric acid in sludge, percent	23	25	25
	Hard, viscous	Soft, of readily pumpable viscosity	

Subsequent tests on the pressability of the acid-treated distillates showed no differences between the two methods of treating.

In another series of tests an East-Texas overhead cylinder stock was treated. Acid-treating rates were

varied from 25 pounds to 50 pounds of 66-deg.-Beaume acid per 50-gallon barrel. Results using 30 pounds of acid in the continuous unit were found comparable to a 50-pound treat in batch treating, and the data are presented on the basis of this comparison.

The characteristics of the untreated East Texas overhead cylinder stock follow:

Gravity, deg. A.P.I.	23.5
Viscosity at 210 deg. F., Saybolt seconds	135
Color, A.S.T.M. No.	*7
Pour point, deg. F.	125/130
Carbon residue, percent	1.8

*Color, 5 A.S.T.M. at still, darkening rapidly on heating for transfer.

	Batch	Continuous (50 Percent Naphtha Dilution)
Quantity of acid, lb. 66-deg.-Beaume per 50 gal.	50	30
Treating temperature, deg. F.	60	60
Refining loss, percent	30	25
Sludge characteristics	Very hard, viscous	Comparatively soft
Neutralization No., mg. potassium hydroxide per gram	0.95	0.37
Naphtha in sludge, percent	12	11.0
Color, A.S.T.M. No. (reduced)	5	4
Filter yield, percent	100	135

Laboratory and plant runs have consistently demonstrated that in a continuous system, with centrifugal separation, a better color is obtained with a given amount of acid, or the same color is obtained with aproximately 25 percent to 50 percent less acid. Experience has shown that continuously-treated oil is equally as well refined—even with the lower acid treats—as oil produced in the batch agitator; and, further, that oils of the same color produced by the two methods possess the same dewaxing characteristics in subsequent processing, and yield the same amount of oil of a given color in clay decolorizing.

The increased efficiency of the acid in continuous treating is attributed to the following factors:

1. *Reduced time of contact*: In batch treatment the oil is contact with the sludge for a period of perhaps four to 15 hours. In the continuous unit this period is reduced to less than 10 minutes. Prolonged contact with the sludge is believed to result in re-solution of some of the products of reaction.

2. *Elimination of air contact*: Continued contact with air during the blowing periods tends to darken the treated oil. In the continuous unit, agitation is accomplished by mechanical mixing.

3. *Degree of dispersion of acid*: Accepting the theory that the reactions taking place during acid treating are surface reactions, then dispersion by mechanical means is certain to be more complete than that achieved by the cruder diffusion with air agitation—presenting more surface by greater division of the acid.

The acidity of the oil after centrifugal separation is much less than that of the acid from batch agita-

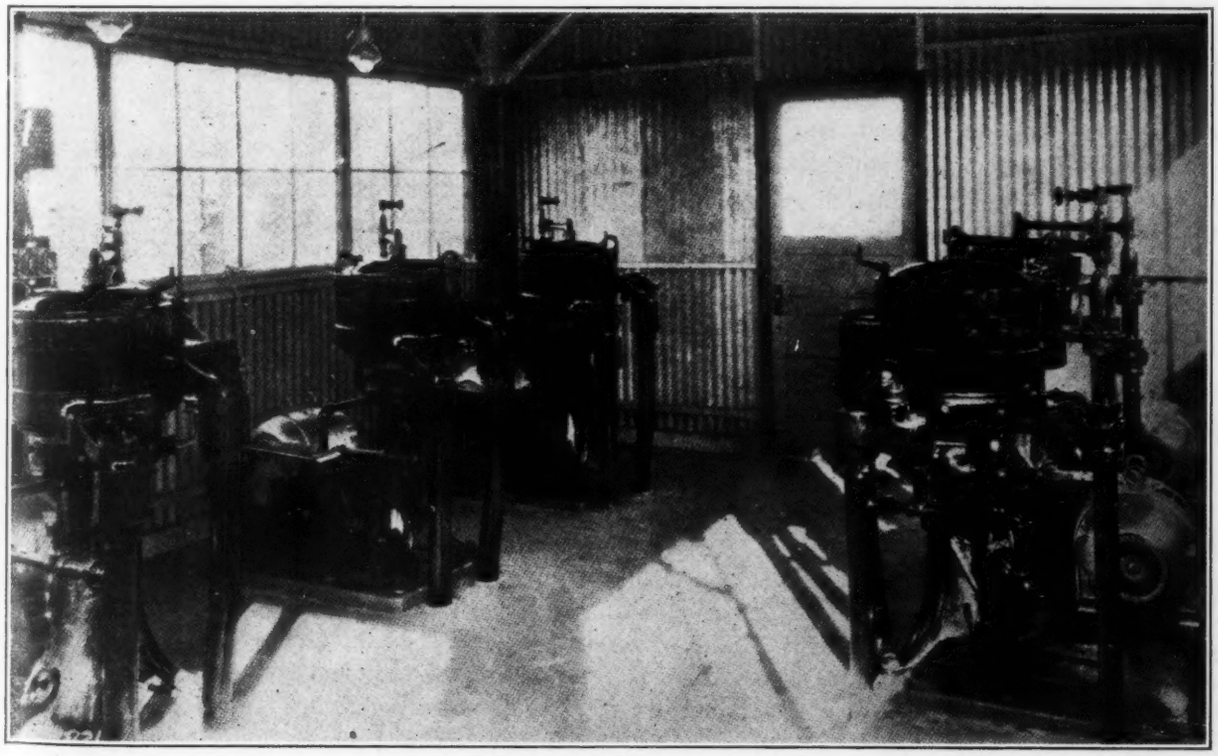

FIGURE 3
An Installation of Centrifugal Acid-Sludge Separators on the Pacific Coast.

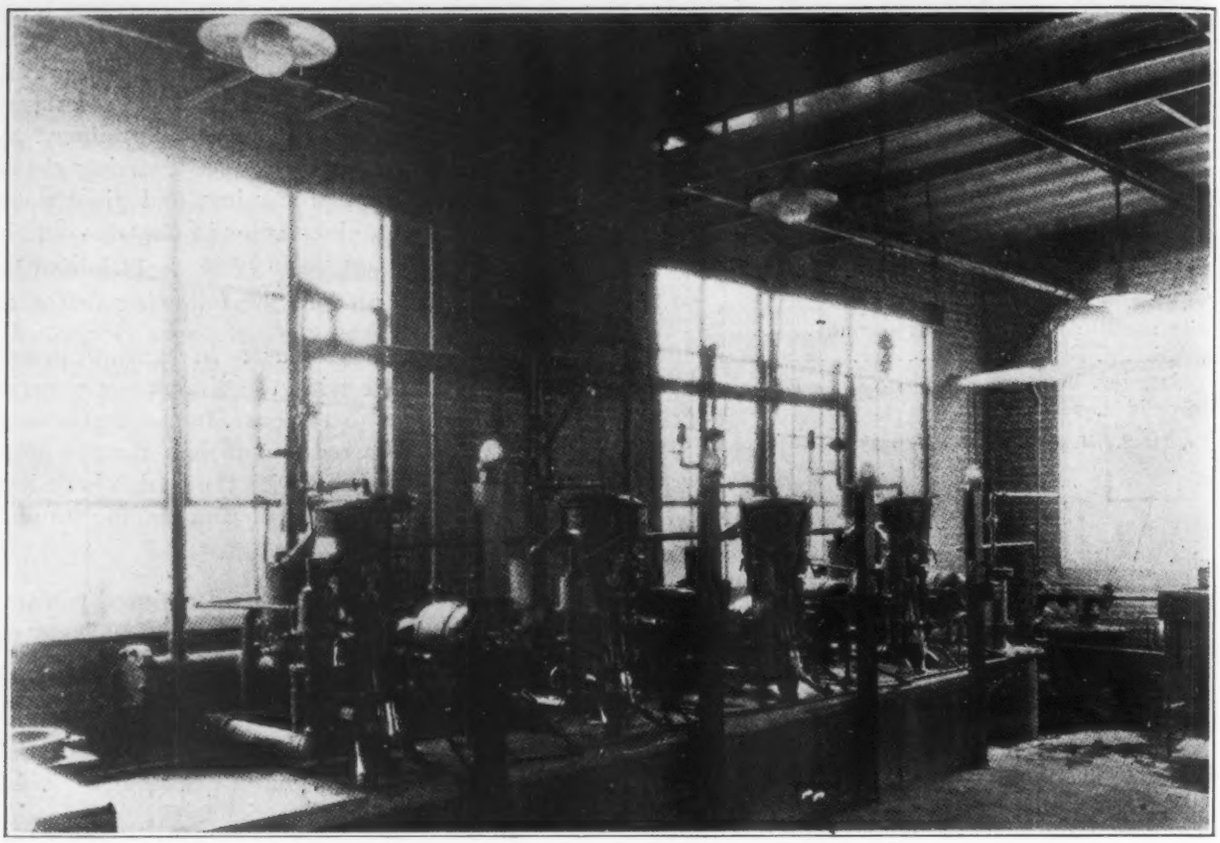

FIGURE 4
Centrifugal Separators Used in Treatment of Light Oils.

tors. In gravity setting rarely is a batch treat made in which all traces of pepper sludge are removed. In addition, weak acid—resulting from "sousing" water —is finely dispersed in the oil, and separates reluctantly. In centrifugal separation both of these acid-bearing materials are removed, except for a trace, and a substantial reduction in the amount of caustic or other neutralizing agents is effected.

To demonstrate this point Table 1 gives a typical series of samples taken from batch treatment and parallel treatments in the continuous unit. The sediment shown represents the total residue thrown out centrifugally in the high-speed test-tube centrifuge referred to previously.

TABLE 1

Comparison of Batch Treatment and Parallel Treatment in Continuous Unit

Residue in Samples (Percent by Volume)

Sample No.	Batch	Continuous	Neutralization No.
Run 17-A	...	0.01	0.25
Batch 7080	0.27	...	1.1
Run 17-B	...	0.02	0.31
Batch 7081	0.21	...	0.96
Run 17-C	...	0.02	0.29
Batch 7083	0.17	...	0.72
Run 17-D	...	0.04	0.36
Batch 7084	0.24	...	0.89

Likewise, due to the more complete seperation of acid and oil when centrifugal separation is used, the treating loss is in all cases reduced. The extent of this reduction is, of course, dependent upon the oil being handled; but, in general, it can be said that this reduction amounts to about one-quarter to one-half of the treating loss encountered in batch treatment. In the drawing off of settled sludge from an agitator some oil is inadvertently, and in some cases deliberately, drawn in order to remove the last traces of sludge. This loss increases with the viscosity of the oil treated and with the quantity of sludge produced, but is eliminated completely by the centrifuge.

Sludge produced in the plant batch treatment is generally hard and viscous by virtue of prolonged contact and air blowing. In some refineries, which do not operate acid-recovery plants, the weak acid from the plant sludge is recovered by steam cooking and decantation, with subsequent mixing of the sludge cake with fuel oil for burning. The primary purpose of recovering this acid is to effect disposal of the sludge; as the cost of labor, steam, and maintenance may quite readily exceed the value of the acid recovered.

In the continuous unit a partial separation of the weak acid sludge is effected in the centrifugal bowl. The weak acid discharging from the acid nozzles may

be collected and fortified or concentrated for re-use. The sludge discharge from the centrifuges, being decidedly less viscous than plant sludge, may be readily pumped; and in most cases can be fed directly to burners under boilers without further treatment—thus eliminating costly "cooking procedure."

ADVANTAGES OVER BATCH TREATMENT SUMMARIZED

To summarize, a large number of tests on oils of widely different characteristics have shown that continuous treatment with centrifugal sludge separation as compared with batch treatment will, in general, show the following advantages:

1. A saving of 25 percent to 50 percent in acid requirements.
2. A saving of 25 percent to 50 percent in earth or neutralizing agents. (Roughly speaking, on most oils a 25-percent saving in both acid and earth can be obtained, or a larger saving in acid, say, 50 percent—assuming that the same quantity of earth will be used.)
3. A reduction of treating loss amounting to 25 percent to 50 percent of that encountered in batch treatment.
4. The oil produced by continuous treatment is generally more stable than that which is treated in agitators.
5. The sludge discharged from the centrifugal machines is less viscous, and more readily disposed of, than that drawn off the agitators.
6. Greater flexibility of operation.

The Problem *of the* Viscosity of Lubricants

(*Continued from page 223*)

to 55 Saybolt seconds were measured accurately in the modified Ostwald pipettes described above. A smooth curve was drawn through the points obtained by plotting the kinematic viscosity at 210 deg. F. vs. the kinematic viscosity at 100 deg. F. In Table 3 are the viscosity characteristics for these light Pennsylvania oils expressed in kinematic viscosity. These values are read from the smooth curve which follows the experimentally-determined points very closely. The greatest deviation for any of the 95 points from the curve is 1 percent.

In order to have a better viscosity-index basis for light oils, a sample of oil, supposedly definitely related to the oil used to define the original 0 viscosity-index oil, was fractionated to get the necessary range in viscosity so that accurate kinematic viscosities on these fractions might also be available. However, on fractionation the viscosity indexes of the fractions varied from + 28 to — 23. It was decided that the 0 viscosity-index oil was not as definite and homogeneous as the 100 viscosity-index oil. In order to establish a viscosity-index table for light oils, it seems best to let the 0 viscosity-index oil be defined as given by Davis, Lapeyrouse, and Dean,[6] but in terms of kinematic viscosity—rather than have the 0 viscosity-index oil relate to any definite material. However, the 100 viscosity-index oils do relate to a definite crude, and for this reason the data in Table 3 should be useful not only in establishing a viscosity-index table for light oils above 100 viscosity-index in terms of some basis perhaps as indicated in connection with Figure 9, but also by using these data together with the data of Dean, Lapeyrouse and Davis on the 0 viscosity-index oils in kinematic units to establish more accurate tables for all light oils. The tables could either be a simple correction to the commonly used table of Dean and Davis[7] in terms of Saybolt seconds, or new tables might be established in terms of kinematic viscosity. The use of tables in terms of Saybolt seconds would require definite and universally-established conversion data for the relationship between kinematic viscosity and Saybolt seconds. This will be forthcoming when the proper procedure for determining Saybolt viscosity is agreed upon.

ACKNOWLEDGMENT

The authors are indebted to the members of the laboratory staff for the data presented. Without their earnest and diligent help this report would not be possible. In addition, this work is part of a research program for the Pennsylvania Grade Crude Oil Association. This material is published with the permission of the School of Chemistry and Physics and of the association.

BIBLIOGRAPHY

[1] *J. Rheology* **2**, 167 (1931).
[2] F. H. Garner and C. I. Kelly, *Physics* **4**, 97 (1933).
[3] J. MacMichael, *J. Ind. Eng. Chem.* **7**, 961 (1915).
[4] Bingham, *Fluidity and Plasticity*, p. 76, McGraw-Hill Book Co., New York (1922).
[5] E. W. Washburn and G. V. Williams, *J. Am. Chem. Soc.* **35**, 737 (1913).
[6] G. H. B. Davis, M. Lapeyrouse, and E. W. Dean, *Oil Gas. J.* **30**, no. **46**, 92 (1932).
[7] E. W. Dean and G. H. B. Davis, *Chem. Met. Eng.* **36**, 618 (1929).

The Relation of Fuel Octane Number *to* Engine Compression Ratio

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EVER since the anti-knock value of fuel became of importance in the operation of automobiles, there has been a natural desire for some kind of formula that would connect engine compression ratio and the octane number of the required fuel. From time to time classifications of cars have appeared which designated certain cars as of the high-compression type and requiring fuel of high octane number, and others of the low-compression type suitable for use on lower-grade fuels. Usually the separation has been made on the basis of absolute volumetric compression ratio, all cars having engines with compression ratios in excess of, say, 5.5 to 1 appearing in the high-compression group.

It would be extremely convenient if such a relation between compression ratio and fuel requirement should exist, but actually there is no necessary connection. Engine design and conditions of operation cover a wide range, and compression ratio is only one of a large number of factors which influence the required fuel octane number.

A somewhat analogous problem is presented when attempts are made to measure the anti-knock value of fuels by means of chemical tests such as gravity and unsaturation measurements. Fuels consist of many series of definite chemical compounds; and, while it may be possible to develop a definite relation between anti-knock value and certain physical characteristics of a given series of compounds, such equations would be quite different for the various series, and the task would become more hopeless.

One definite relation exists between anti-knock value and compression ratio: the higher the compression ratio of a given engine, the higher is the octane number of the fuel required for equally satisfactory operation—other factors remaining the same. It is, therefore, interesting to note the general trend of automobile compression ratios and power output in the period during which the oil industry has been improving the anti-knock value of the available fuels. Perhaps of greater significance is a study of the engine factors which control the power-production possibilities of a given fuel. This paper attempts briefly to consider these two phases of the fuel-utilization problem.

Paper Presented at Fourth Mid-Year Meeting, American Petroleum Institute, at Pittsburgh, Pennsylvania, May 24, 1934.

FIGURE 1 shows graphically the average percentage change in the displacement, speed, compression, and horsepower of passenger-car engines since 1925, based on models listed in trade publications. A brief inspection of the curves is sufficient to indicate the remarkable strides which have been made during the past nine years in the development of the automobile engine. Average power output has been increased 88 percent. The horsepower of the cheaper, and by far the most numerous, cars is now 2 to 4½ times the 1925 figures.

Increases in power must necessarily come from increases in one or more of the following:

1. Displacement.
2. Speed.
3. Brake mean effective pressure.

Figure 1 shows that the average engine now has 14 percent greater displacement than in 1925, and that there has been no change in this figure during the past two years. The automobile-engineering fraternity is convinced of the folly of a displacement race, and is concentrating its efforts on a better utilization of a given cylinder capacity and weight of metal.

The average 1934 engine has a power-peaking speed 30 percent higher than in 1925, and there is no indication that the limit has been reached. Because of the high torque requirement of the automobile engine over its entire speed range, it has not been possible to alter valve timing to favor the higher speeds; instead the better high-speed performance has resulted almost entirely from freer breathing and higher compression pressures, which also improve low-speed torque.

Brake mean effective pressure at the power-peaking speed has increased 27 percent. In other words, every cubic inch of engine delivers 27 percent more power at a given speed than it did in 1925; and, at the same mixture ratio, there is a corresponding improvement in specific economy. Average compression ratios have gone up 30 percent, and compression pressures at least 46 percent. The data for the latter curve were obtained from published data on compression ratios in conjunction with average data on the relation of compression pressure to compression ratio in modern engines. It is known that restricted breathing of the earlier engines produced a lower compression pressure at a given compression ratio and, consequently, a lower volumetric efficiency. Higher compression ratios and improved volumetric efficiency are responsible for the higher

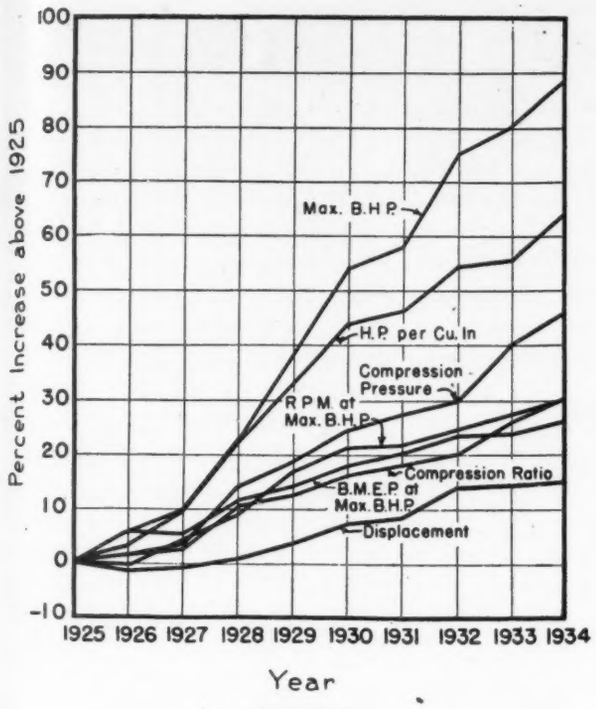


FIGURE 1

Average of values listed in trade publications. Trends of American Passenger-Car Engine Design Since 1925

brake mean effective pressure of the present automobile engine.

Compression ratios of 1934 cars range from 4.95 to 7.18, whereas in 1925 the spread was from 3.6 to 5.1.

ANTI-KNOCK VALUE AND ENGINE DESIGN IMPROVE

It is apparent, therefore, that the steady improvement in the anti-knock value of fuels which the oil refiner has made during the past nine years has contributed to progressive engine design in four ways:

1. By suppressing the detonation which normally results from an increase in volumetric efficiency.

2. By permitting higher engine speeds obtained by the higher volumetric efficiency, and by eliminating the knock which tends to increase with speed in certain types of engines.

3. By making possible improved cyclic efficiency through higher compression pressures.

4. By overcoming the greater knocking tendency of the larger displacement cylinders which have appeared in certain cars.

REFINER AIDS ENGINE-OPERATING FACILITY

Increased detonating tendency has always confronted the automotive engineer, regardless of the direction in which he has turned in his search for more power; hence improved fuels have largely contributed to making his achievements possible. A gallon of gasoline is no larger today than it was in 1925, but its hidden potentialities account for the major portion of the 88 percent increase in average engine horsepower. The average car owner probably takes for granted the availability of gasoline suitable for the new car he purchases without realizing the part the refiner has played in advancing his motoring pleasure, convenience, and economy.

As has been stated previously, there is no general definite relation between permissible compression ratio and fuel octane number. A glance at the compression ratio specifications of the 1934 cars might lead to the conclusion that engine designers have varied widely in the degree to which they have utilized the fairly uniform grades of gasoline which have been made available by refiners. Actual tests of the cars do not confirm this conclusion, and one is forced to accept the fact that the problem is somewhat complicated.

TEN VARIABLES CONTROL COMPRESSION RATIO

Research and experience have shown that the compression ratio which may be used with a given fuel is influenced by the following 10 variables:

1. Engine design.
2. Cylinder size.
3. Materials of construction.
4. Carbonization, rusting, and liming.
5. Engine speed.
6. Jacket temperature.
7. Mixture ratio.
8. Mixture temperature.
9. Volumetric efficiency.
10. Ignition timing.

The known facts in reference to the above-mentioned variables are voluminous, and the scope of this paper permits only a brief consideration of each.

ENGINE DESIGN AFFECTS COMPRESSION RATIO

Engine design, in relation to knocking tendency, has been a subject of debate since detonation began to impose limits on engine output, and the complexity of the problem is probably ample assurance that the discussion will be continued. For the purpose of illustration, engines may be roughly divided into two classes, viz.: L-head and valve-in-head. Other things being approximately equal, the valve-in-head engines permit considerably lower compression ratios on a given fuel than do L-head engines, but the lower ratios produce a power output comparable with the higher ratios of the latter. Thus an explanation is immediately offered for a substantial portion of the variation in compression ratio of the 1934 cars.

The compression ratio that may be used on a given type of engine is influenced materially by the provisions made for cooling the cylinder elements which normally attain the highest temperatures. Figure 2 shows the additional brake mean effective pressure that was obtained by increased throttle opening of a high-compression single-cylinder engine made possible on the same fuel by abnormal cooling of the exhaust valve and piston. The piston was cooled by a spray of soap suds

against the under side, the same liquid having been used also for crankcase lubricant. The exhaust valve was hollow, as shown in Figure 3, and was cooled by the circulation of cold water through the stem and head.

The percentage gains in power output would not have been so large had the throttle opening been kept constant and the increased compression pressure gained by increases in compression ratio, but would have been of approximately the same magnitude had an engine operating at full throttle been super-charged. Both of the cooling methods described above are limited to laboratory use, but the results obtained should serve as a goal for engine builders in designing within the limits of practicable possibilities. It may be pointed out that the economical mass production of automobile engines seems to preclude the use of many of the types of construction which have contributed to the superior cooling of aircraft engines.

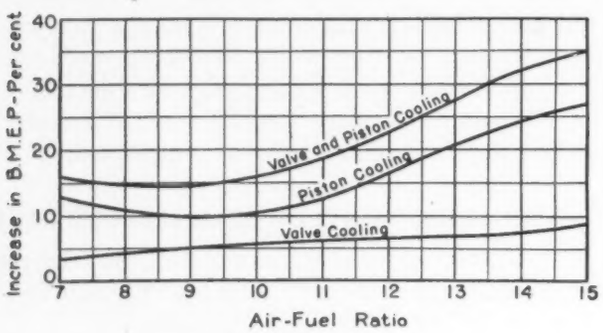


FIGURE 2

L-Head, Single-Cylinder Engine.
Bore, 3¼ in. Stroke, 5 in.
Jacket temperature 212° F.
Spark advance, maximum power.
Compression ratio, 7.0.
Throttle opening, varied.
Cylinder-head material, cast iron.
Speed, 600 r.p.m.
Air-fuel ratio, varied.
Piston material, aluminum.

The Effect of Abnormal Cooling of Piston and Exhaust Valve on B.M.E.P. of Throttled Engine for Equal Knocking Tendency.

COMPRESSION RATIO AFFECTED BY CYLINDER SIZE

Cylinder size bears a definite relation to permissible compression pressure on a given fuel. Any increase in cylinder dimensions tends to increase detonation tendency; hence the larger cylinders are limited to lower brake mean effective pressures than are possible with the smaller cylinders of the same general design. Figure 4 shows a series of single-cylnder heads and variable-bore blocks used for a study of this variable. Two crankshafts, giving different strokes, were also used. A single-cylinder engine was chosen for a study of this and the other variables covered by the paper because of the better control that could be exercised over the variables not under investigation. Experience has indicated the good correlation of the data with those obtained on multi-cylinder engines, and a few data for the latter engines are included in this paper.

Figure 5 shows the variation in permissible compression ratio on a given fuel for the several combinations of bore and stroke, and Figure 6 shows the variation of indicated mean effective pressure. It is apparent that the smaller cylinders, because of higher permissible compression pressures on a given fuel, develop more power per cubic inch at a higher thermal efficiency than do the larger cylinders.

CONSTRUCTION MATERIALS AFFECT RATIOS

It is definitely known that the thermal conductivity of metals is of much importance in aircraft-engine design. The possible advantages of the more highly-conductive metals in automobile-engine design have not yet been very well evaluated. Figure 7 shows a com-

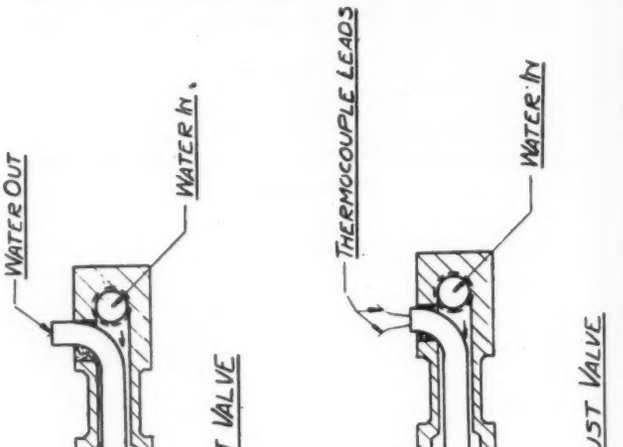


FIGURE 3

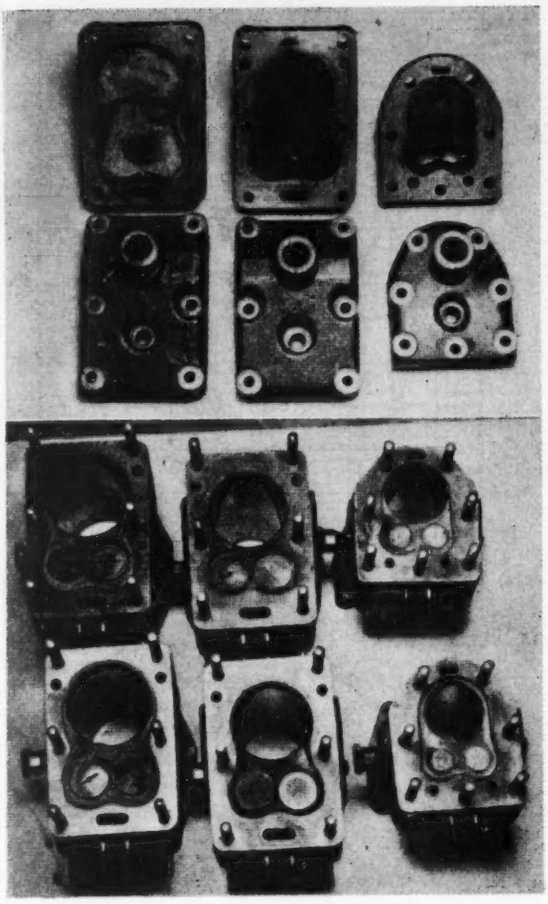


FIGURE 4

Cylinders and Heads Used in Study of Relation of Cylinder Displacement to Fuel Octane-Number Requirement.

parison of iron and aluminum cylinder heads over a range of compression ratios when used on the single-cylinder engine previously mentioned. The data indicate a slightly lower brake mean effective pressure and octane-number requirement for the aluminum heads at the same compression ratio. The brake mean effective pressure at any given octane number is practically identical for the two types of heads which, incidentally, were cast from the same patterns.

Figure 8 shows octane-number requirement and brake mean effective pressure over a wide speed range for an eight-cylinder automobile engine equipped with cast-iron heads of 5.3, 6.3, and 7.0 to 1 compression ratio, and with an aluminum head of 7.0 to 1 compression ratio. In this case the aluminum head shows an advantage of approximately two octane numbers for the same brake mean effective pressure. Both types of heads were cast from the same patterns.

There has been some progress in combustion-chamber design during the past few years, and it is possible that the combustion-chamber shape which is best for cast iron is not the most efficient for aluminum. Comparisons should be made of designs which represent the best achievements to date in the use of the two metals.

The aluminum head has possibly not appeared to best advantage, because it has been made interchangeable with iron heads. Conventional steel cylinder studs have an expansion coefficient entirely different from that of aluminum, and a tendency has been noted for aluminum heads to be crushed under the stud nuts. Under certain conditions of operation the cylinder head may not subsequently be in too good contact with the cylinder-head gasket. It would seem that more attention should be given to higher-expansion cylinder studs and to any other features of design which will minimize the effects of the differential expansion of aluminum and ferrous metals.

CARBON, RUST, AND LIME CAUSE KNOCK

It is common knowledge that cars usually have less tendency to detonate when they leave the factory than at any time afterward. Such a progressive change in knocking tendency may be due to carbonization of the combustion chamber, rusting of the water jacket, or to the deposition of salts from cooling-water additions. Figure 9 shows the increase in knocking tendency of the single-cylinder engine with carbon accumulation. Rust and lime deposits in the water jacket have an effect similar to carbon deposits. It will be noted that deposition, in addition to increasing the knocking tendency, reduces power output.

ENGINE SPEED INFLUENCES KNOCKING

Figure 10 shows that engine speed influences knocking tendency; in fact, many engines show an even

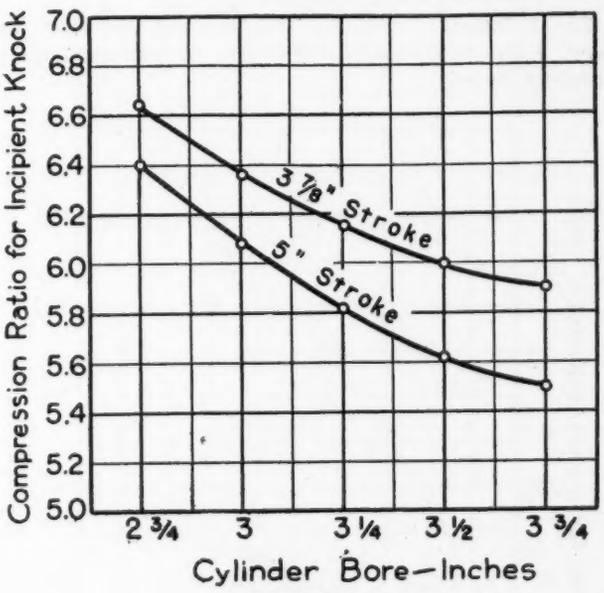


FIGURE 5

L-Head, Single-Cylinder Engine.
Bore, varied.
Stroke, 3⅞-inch and 5-inch.
Speed, 600 r.p.m.
Throttle opening, full.
Cylinder-head material, cast iron.
Fuel octane No., 80.
Compression ratio, carried.
Jacket temperature, 212° F.
Air-fuel ratio, maximum knock.
Spark advance, maximum power.

The Relation of Cylinder Displacement and Fuel Anti-knock Value to Compression Ratio for Incipient Knock.

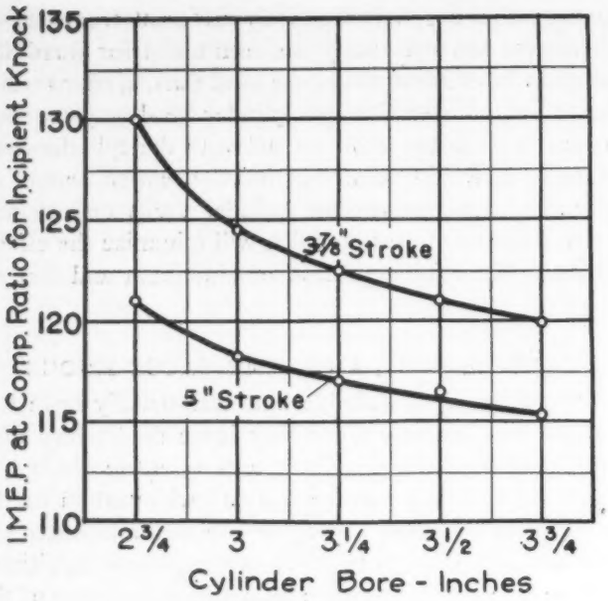


FIGURE 6

L-Head, Single-Cylinder Engine.
Bore, varied.
Stroke, 3⅞-inch and 5-inch.
Speed, 600 r.p.m.
Throttle opening, full.
Cylinder-head material, cast iron.
Fuel Octane No., 80.
Compression ratio, varied.
Jacket temperature, 212° F.
Air-fuel ratio, maximum knock.
Spark advance, maximum power.

The Relation of Cylinder Displacement and Fuel Anti-knock Value to Indicated M.E.P. at Compression Ratio for Incipient Knock.

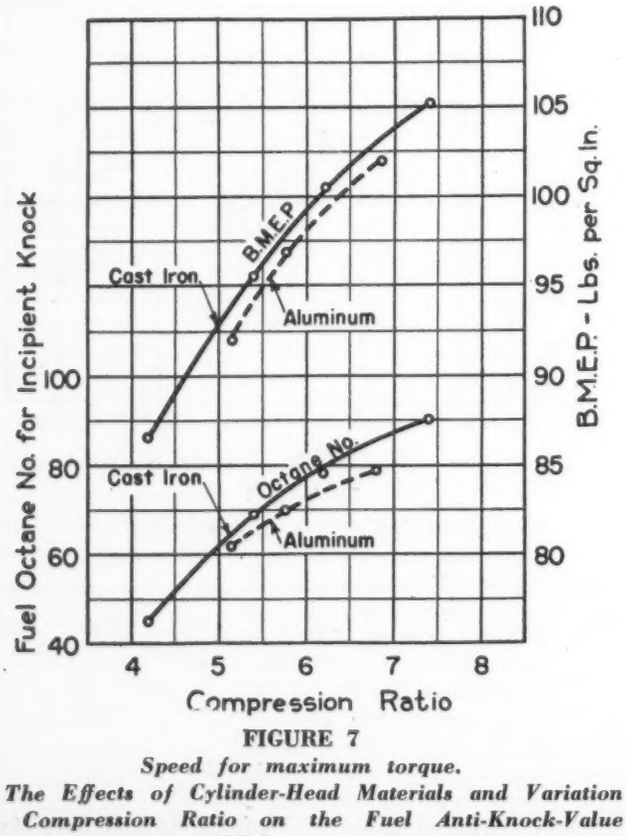


FIGURE 7

Speed for maximum torque.

The Effects of Cylinder-Head Materials and Variation in Compression Ratio on the Fuel Anti-Knock-Value Requirement and B.M.E.P. of a Single-Cylinder Engine.

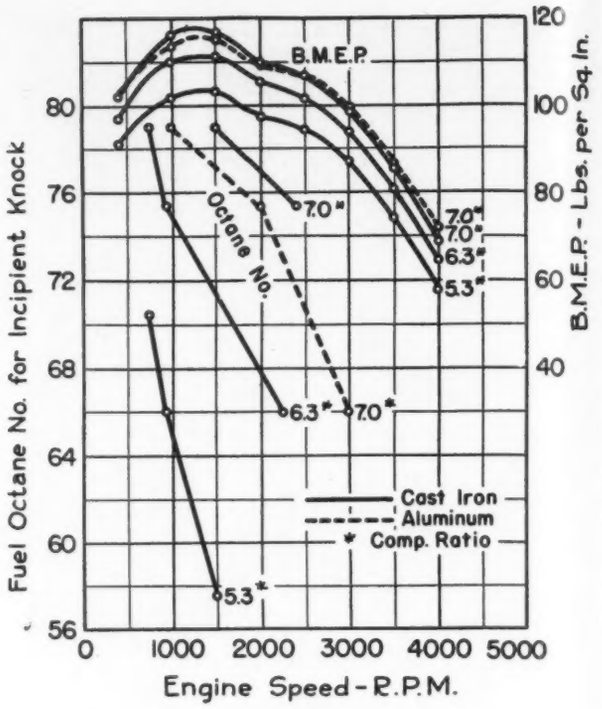


FIGURE 8

The Effects of Cylinder-Head Materials and Variation in Compression Ratio on the Fuel Anti-knock-Value Requirement and B.M.E.P. of an Eight-Cylinder Automobile Engine.

greater change in required octane number for the same speed difference. Other types of engines may have their greatest knocking tendency at other speeds. Observations were not carried beyond 2100 r.p.m. because of the disturbing effect of engine noise. It is apparent that if some means were developed which would prevent an engine from operating under full throttle at the speed of maximum knocking tendency, a higher compression ratio could be used.

JACKET TEMPERATURE AND MIXTURE RATIO FELT

Figure 11 indicates the effect of jacket temperature on octane requirement and torque. Higher temperatures

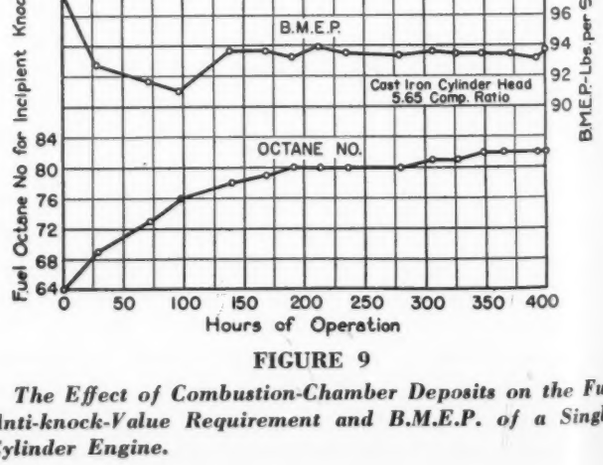


FIGURE 9

The Effect of Combustion-Chamber Deposits on the Fuel Anti-knock-Value Requirement and B.M.E.P. of a Single-Cylinder Engine.

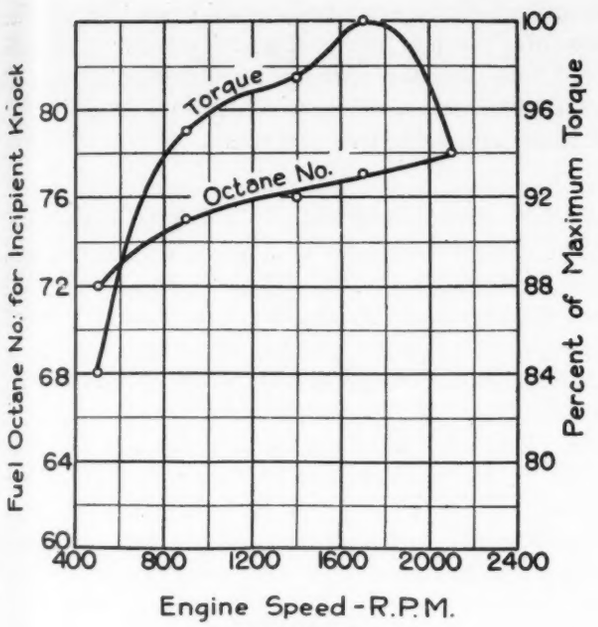


FIGURE 10

Bore, 3¼-inch. Stroke, 3⅞-inch.
Speed in r.p.m., varied.
Intake air temperature, 85° F.
Throttle opening, full.
Cylinder-head material, cast iron.
Compression ratio, 5.75.
Jacket temperature, 190° F.
Air-fuel ratio, 13.5.
Spark advance, maximum power.

The Effect of Variation in Engine Speed on the Torque and Fuel Anti-knock-Value Requirements of a Single-Cylinder Engine.

demand better fuels, and cause a very large sacrifice of torque as well.

Figure 12 shows that mixture ratio affects knocking. A change of air-fuel ratio from 9.4 to 13.0 to 1 changes the octane requirement by 12 units, and a change from 13.0 to 16.0 to 1 permits an octane-number change of 18 units. Obviously, mixture ratio is one of the most important factors in the problem; but, unfortunately, the air-fuel ratio for maximum knock is not far different from that for maximum power; hence little can be done to improve the situation. A multi-cylinder engine with perfect fuel distribution, designed to run at the maximum-economy air-fuel ratio, would run on a lower-grade fuel than one designed for best power; but maximum economy at full throttle is seldom desired, and perfect distribution would necessitate the use of highly volatile fuels or liberal intake-manifold heating, or both —and the latter would tend to increase knocking.

MIXTURE TEMPERATURE TO BE OBSERVED

Figure 13 shows the effect of intake air temperature. The influence of variable heating of the charge in the intake manifold would be similar. As would be expected, the higher temperatures raise the octane requirement, and considerably decrease power output. It is, therefore, highly desirable that there be as little preheating of carburetor air or mixture as possible, and the increasing ability of refiners to supply more volatile fuels permits a reduction in intake-manifold heating.

KNOCK INCREASES WITH VOLUMETRIC EFFICIENCY

Knocking tendency increases along with volumetric efficiency, whether the latter is due to decreased throttling at some point in the induction system or to greater manifold pressure resulting from supercharging or decreased altitude. Figure 14 indicates the effect of throttling a single-cylinder engine. Both octane requirement and torque are reduced as manifold vacuum increases. When the former is reduced from 75 to 64, engine torque is reduced by 20 percent. It is obvious that throttling is a most inefficient method of reducing knocking tendency. A reduction in compression ratio is much to be preferred.

It should be pointed out that because of the surging of the intake-manifold pressure of a single-cylinder engine and the consequent difficulty of measurement, the manifold vacuum shown in Figure 14 is only relative.

IGNITION TIMING AFFECTS FUEL CONSUMPTION

Ignition timing is a well-known factor with influences fuel requirement. Figure 15 shows the effect of spark advance on octane number and torque for a

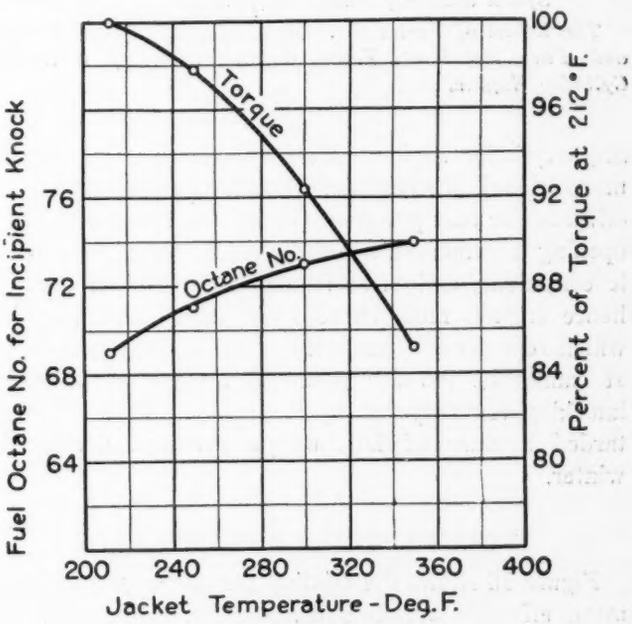


FIGURE 11

Bore, 3¼-inch. Stroke, 3⅞-inch.
Speed, 800 r.p.m.
Intake air temperature, 85° F.
Throttle opening, full.
Cylinder-head material, cast iron.
Compression ratio, 5.4.
Jacket temperature, ° F., varied.
Air-fuel ratio, 13.5.
Spark advance, maximum power.

The Effect of Variation in Jacket Temperature on the Torque and Fuel Anti-knock-Value Requirements of a Single-Cylinder Engine.

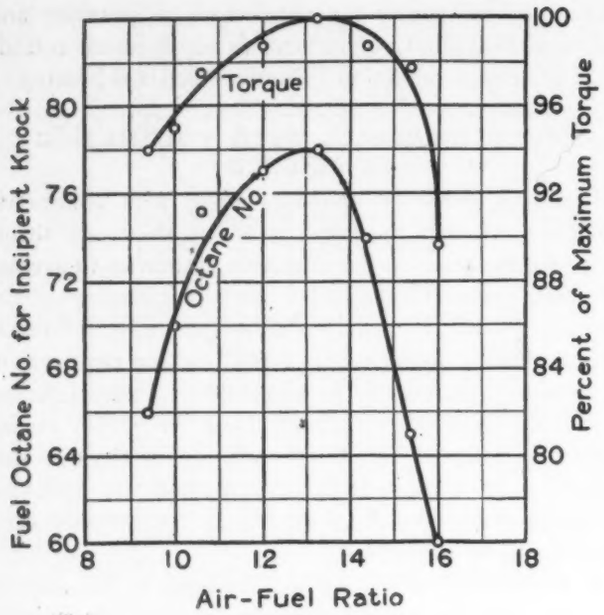


FIGURE 12

Bore, 3¼-inch. Stroke, 3⅞-inch.
Speed, 800 r.p.m.
Intake air temperature, 85° F.
Throttle opening, full.
Cylinder-head material, cast iron.
Compression ratio, 5.75.
Jacket temperature, 190° F.
Air-fuel ratio, varied.
Spark advance, maximum power.

The Effect of Variation in Air-Fuel Ratio on the Torque and Fuel Anti-knock-Value Requirements of a Single-Cylinder Engine.

single-cylinder engine. Multi-cylinder engines may be more critical. It should be borne in mind that the spark advance for best power at any engine speed or throttle opening is influenced by engine temperature, atmospheric conditions, carbon accumulation, and other factors; hence engines must be sent out with a spark setting which represents a compromise for average conditions. It cannot be too far advanced because of excessive knocking tendency during the summer or too far retarded because of lack of performance during the winter.

PROBLEM IS ONE FOR RESEARCH

Figure 16 shows the relation for one engine of brake mean effective pressure, compression ratio, spark advance, and knocking tendency at one speed and wide-open throttle; and indicates an interesting field for research on performance and economy. It will be noted that for a fuel of a given octane number there is a combination of compression ratio and spark advance which produces the maximum brake mean effective pressure, and that the spark advance is retarded from the maximum power setting determined for the same compression ratio when a non-knocking fuel was used. At other speeds and compression ratios different relations between brake mean effective pressure and spark advance, determined on the same fuel, would exist. The problem, therefore, becomes one of determining for a range of speed and throttle opening the combination of the above-mentioned variables which will produce the highest brake mean effective pressure.

RATIO NOT CHANGED DURING OPERATION

The compression ratio of a given engine cannot be changed during operation, and the ratio that should be used is determined by the knocking tendency of the engine at the speed at which knocking is most pronounced. If maximum average economy over a wide range of operating conditions is desired, a compression ratio should be chosen which, under the conditions stated in the preceding sentence, requires the retardation of ignition timing below the best power setting for the elimination of knock on the fuel under consideration; but in no case should such a high ratio be chosen that the power developed with retarded spark is less than that at the highest compression ratio which permits maximum spark advance on the same fuel without knock. The latter is represented in Figure 16 by point A, and the former by point B. At any compression ratio between these two points the thermal efficiency is higher than at A, and the heat dissipation problem correspondingly less.

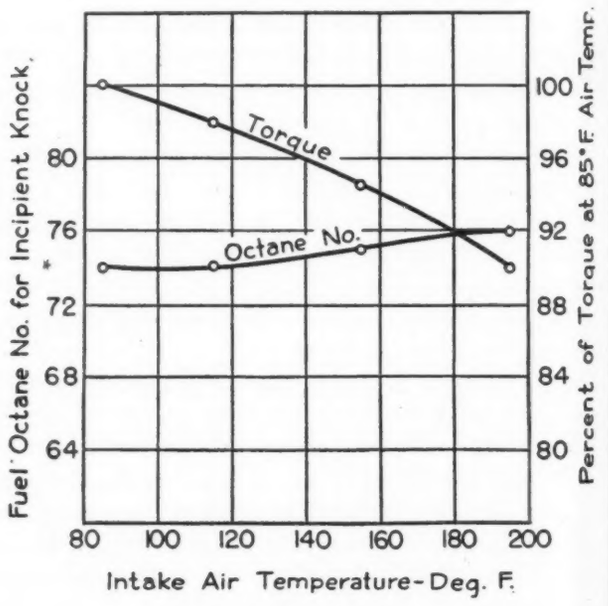


FIGURE 13

Bore, 3¼-inch. Stroke, 3⅞-inch.
Speed, 800 r.p.m.
Intake air temperature, varied.
Throttle opening, full.
Cylinder-head material, cast iron.
Compression ratio, 5.75.
Jacket temperature, 190° F.
Air-fuel ratio, 13.5.
Spark advance, maximum power.

The Effect of Variation in Intake Air Temperature on the Torque and Fuel Anti-knock-Value Requirements of a Single-Cylinder Engine.

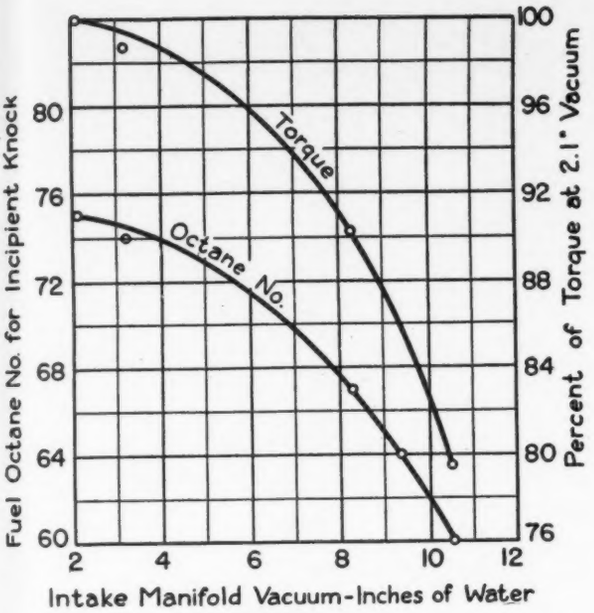

Fuel Octane No. for Incipient Knock
Percent of Torque at 2.1" Vacuum
Torque
Octane No.
Intake Manifold Vacuum-Inches of Water

FIGURE 14

Bore, 3¼-inch. Stroke, 3⅞-inch.
Speed, 800 r.p.m.
Intake air temperature, 85° F.
Throttle opening, varied.
Cylinder-head material, cast iron.
Compression ratio, 5.75.
Jacket temperature, 190° F.
Air-fuel ratio, 13.5.
Spark advance, maximum power.

The Effect of Variation in Throttle Opening on the Torque and Fuel Anti-knock-Value Requirements of a Single-Cylinder Engine.

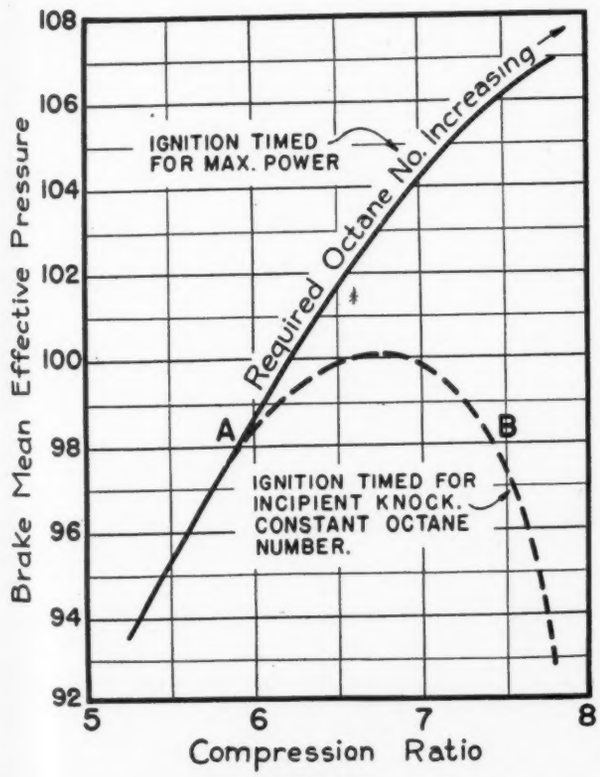


FIGURE 16

Relation Between B.M.E.P., Octane No., Ignition Timing, and Compression Ratio at Constant Speed.

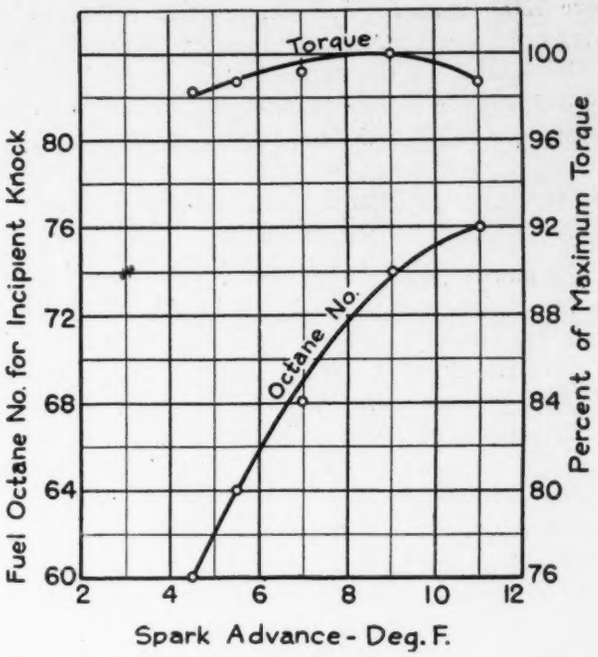


FIGURE 15

Bore, 3¼-inch. Stroke, 3⅞-inch.
Speed, 800 r.p.m.
Air intake temperature, 85° F.
Throttle opening, full.
Cylinder-head material, cast iron.
Compression ratio, 5.75.
Jacket temperature, 190° F.
Air-fuel ratio, 13.5.
Spark advance, varied.

The Effect of Variation in Ignition Timing on the Torque and Fuel Anti-knock-Value Requirements of a Single-Cylinder Engine.

ECONOMY AND PERFORMANCE GAINS REPORTED

At other speeds at wide-open throttle, and at all speeds at partial throttle, the knocking tendency will be less; and the spark may be advanced as far toward the maximum-power setting as knocking will permit. The actual maximum-power setting can be used over a wide range of conditions, particularly at partial throttle. Under such conditions full advantage is taken of the increased compression ratio. The adjustment of ignition timing required for the operation described above can be obtained by the careful design of a distributor mechanism actuated by changes in engine speed and intake-manifold vacuum. The proper characteristics must be worked out by careful dynamometer tests. Substantial gains in fuel economy, and some increase in performance over that obtainable through the use of the maximum-power spark advance at wide-open throttle over the entire speed range, have been reported as a result of preliminary tests.

OCTANE NUMBER VS. COMPRESSION RATIO AND TORQUE

Figure 17 shows the influence of octane number on the permissible compression ratio and torque of a large multi-cylinder engine. For the suppression of knock

above 1200 r.p.m. the 5.27 compression ratio requires a 78.7 octane fuel, and the 4.40 ratio a 71.2 octane fuel. At the same speed the torque is 445 for the low ratio, and 495 for the higher ratio, or a difference of more than 11 percent for 7.5 octane numbers.

PUBLIC, REFINER, ENGINE DESIGNER COOPERATE

In summarizing, it is apparent that any engine having the variables of operation adjusted for minimum knocking tendency could be run at some fraction of its potential output on almost any fuel at any reasonable compression ratio; hence a correlation of octane number and compression ratio is impossible. However, over-rich mixtures, low volumetric efficiency, and excessively-retarded ignition timing are poor substitutes for anti-knock value in the fuel.

The public, the refiner, and the engine designer will all profit from a better utilization of the anti-knock value of gasoline, and greatest progress can be made through the cooperation of the three interested parties. The engine designer can make an effort to keep cylinder sizes within the efficient limits, provide for the cooling of cylinder parts whose temperatures materially affect knocking tendency, and make an effort to utilize the more volatile fuels. The refiner can strive for lower vapor pressure and better anti-knock stability of the lighter fuels. The motorist can assure himself of a full measure of the additional performance made possible through the cooperation of refiner and engine designer by operating his car on the recommended fuels, and by maintaining as nearly as possible the original engine condition and adjustments.

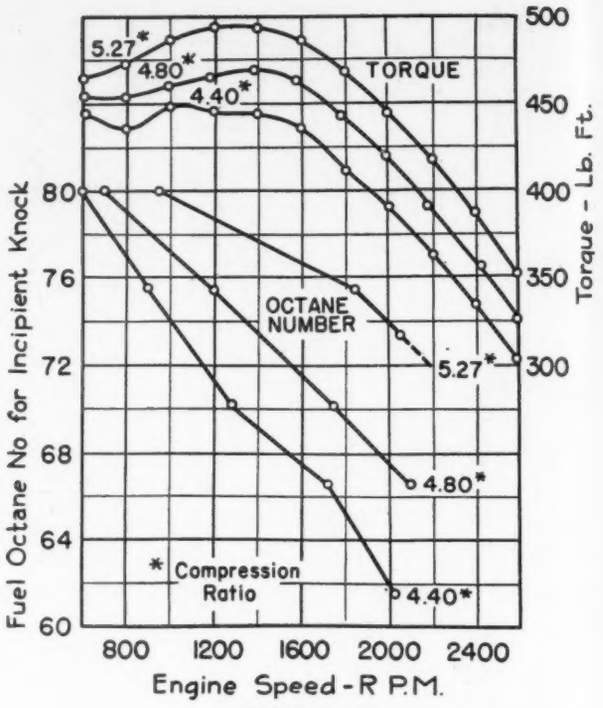
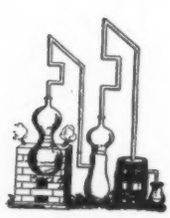


FIGURE 17

Bore, 4⅞-inch. Stroke 5½-inch. Number of Cylinders, 6. The Fuel Anti-knock-Value Requirements and Torque of a Large Multi-cylinder Engine at Three Compression Ratios.



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by

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Traver Road, Ann Arbor, Mich.

under the supervision of

DR. E. H. LESLIE and DR. H. B. COATS

The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

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Fundamental Physical Data

Heat Content of Gases from 0° to 1000 C. G. B. TAYLOR. *Ind. Eng. Chem.* **26** (1934) p. 470.

Process calculations involving heating or cooling of gases require a knowledge of heat content. However, reference books ordinarily give no data for heat content but, instead, supply formulas for specific heat. The author calculated the heat content of the individual gases by integrating Bryant's equation for specific heat at constant pressures. The heat content of diatomic and polyatomic gases are presented in tabular form over the range 0° C. to 1900° C.

Line Coordinate Charts for Vapor Pressure-Temperature Data. F. E. E. GERMANN AND O. S. KNIGHT. *Ind. Eng. Chem.* **26** (1934) pp. 467-70.

The methods that have been used to represent vapor pressure-temperature data are briefly reviewed. The authors believe that the data are best first reduced to straight lines and that these lines should then be plotted as points on line coordinate charts. As a result of a critical review of the vapor pressures of organic liquids, 183 organic liquids and solids were found with vapor pressures well known in the range 500-900 mm. of mercury. These as well as water have been represented on the charts. Charts nine inches by 24 inches can be read to 0.25° C. or to two mm. pressure.

Spontaneous Ignition Temperatures of Hydrocarbon-Air Mixtures. D. T. A. TOWNEND AND L. L. COHEN. *Chem. & Ind.* **53** (1934) pp. 267-69.

The authors refer to the work of Coffey and Birchall that reveal two spontaneous ignition zones and to their own previous work on the influence of pressure on spontaneous ignition that had shown ignition points located in two widely separated temperature ranges. The pressure work has been extended to cover many combustibles over wide ranges of experimental conditions. It is important to discriminate between two types of ignition; first, that resulting in so-called "cool" flames, and the other resulting in true ignition. The cool flames are slow-traveling bluish flames that result in small, but fairly rapid pressure development and the gaseous products of which are rich in substances of aldehydic character. Upon true ignition, however, there is brilliant light emission, accompanied by much greater pressure development and the products are practically free from intermediate oxygenated bodies. True ignition in the lower temperature range is a comparatively rare phenomenon with hydrocarbon-air mixtures at atmospheric pressure. Increase of pressure much above atmospheric leads to the development of true ignition which follows the cool flame immediately. The relationship of ignition point and pressure are discussed and also depicted graphically. Generally speaking, it appears that knock in an engine is related to a compression ratio adequate to allow spontaneous true ignition in the lower temperature range which lies within the ordinary working temperature of gasoline-air engines.

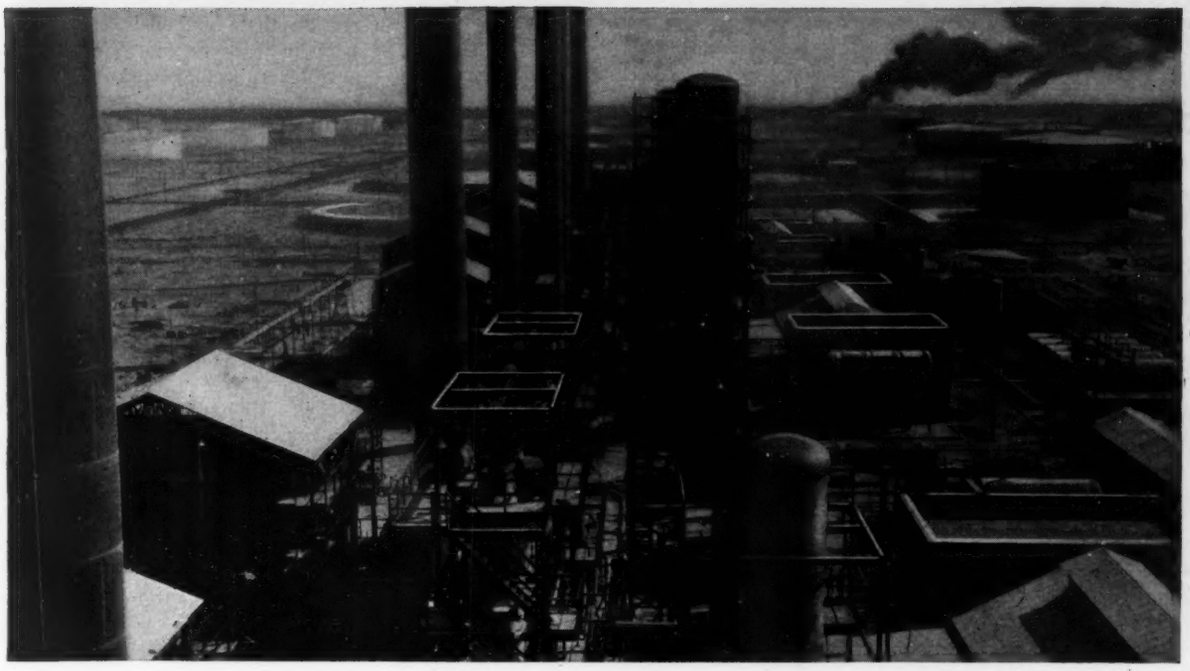
Viscosity Index Charts. P. DOCKSEY, C. H. G. HANDS, W. A. HAYWARD. *Jour. Inst. Pet. Tech.* **20** (1934) pp. 248-54.

The American literature on the subject of viscosity index is reviewed and it is concluded that the method of Dean and Davis is, all things considered, most suitable. The authors then proceed to explain the development of charts applying the Dean and Davis method, which charts will be convenient from the viewpoint of workers in England or on the continent. Viscosities are expressed in centistokes. The range is extended to include oils of high viscosity.

Chemical Composition and Reactions

The Chemical Evidence for the Low-Temperature History of Petroleum. B. T. BROOKS. *Jour. Inst. Pet. Tech.* **20** (1934) pp. 177-205.

Since it is only recently that we have known what petroleum is chemically it is not surprising that there should have been such a variety of theories as to its origin. Such theories as that of the action of water on metallic carbides and the more recently proposed theory of its formation by the action of alpha radiation on methane have disregarded such details as the chemical nature of petroleum and the geological circumstances of its occurrence. Our recently acquired chemical knowledge of petroleum strongly supports the idea that petroleum has had throughout a low temperature history. The Engler theory, according to which the oil was formed by the action of heat upon fatty acids or other organic matter, can hardly be seriously considered today. The chemical composition of petroleum is reviewed. No petroleum has ever been found containing unsaturated hydrocarbons of the ethylene type. Petroleums containing nitrogen bases decompose at temperatures showing that these petroleums have never at any time been subjected to a temperature as high as that of distilling kerosene. The probable source materials of petroleum are listed and the possible chemical changes by which petroleum may have been formed are briefly considered. The di-



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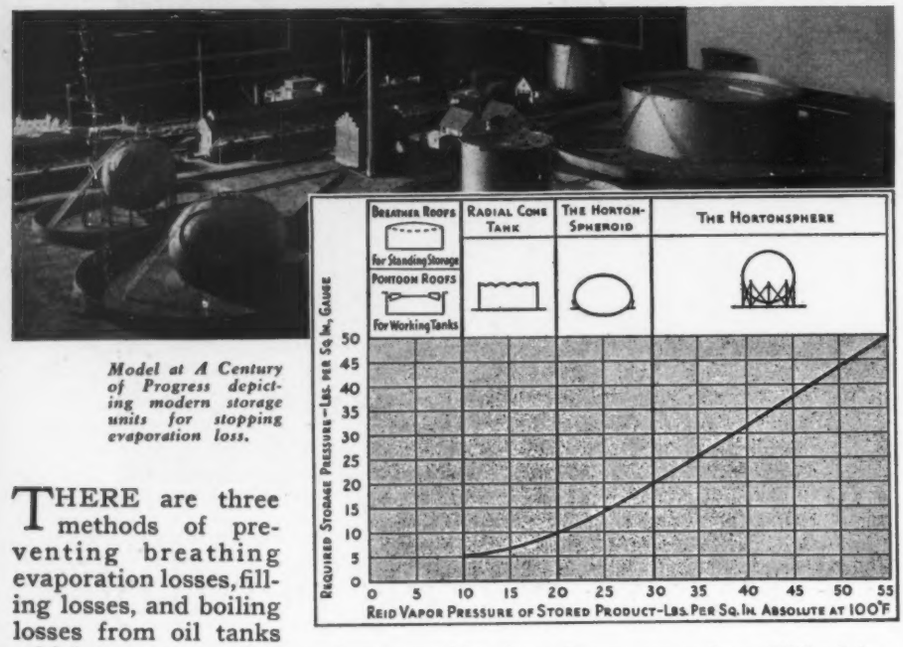

Model at A Century of Progress depicting modern storage units for stopping evaporation loss.

THERE are three methods of preventing breathing evaporation losses, filling losses, and boiling losses from oil tanks which are economical and reasonably free from operating difficulties, (1) the use of a variable vapor space, (2) the elimination of vapor space, and (3) pressure storage. Although a careful analysis of each proposed installation is necessary to determine the most economical storage unit, the chart above indicates the relation of vapor pressure to the preferred type of tank.

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This roof provides a vapor space with a variable volume. The vapor can expand without being forced out of the tank and can contract without drawing in fresh air. A Breather roof is suitable for standing storage of crude oil or gasolines which do not boil under atmospheric pressure at the maximum temperature likely to be reached by the liquid surface. This includes all ordinary motor gasolines. This roof is specially advantageous on tanks of large diameter, having maximum breathing capacity per square foot of area.

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rection that further investigation should take in order to determine the origin of petroleum is suggested.

Application of Raman Spectrography to the Study of Gasoline. A. ANDANT. *Chimie and Industrie,* **30** (1933) pp. 1011-19.

A detailed account is given of the Raman spectrographic examination of five different gasolines. Gasolines from Sumatra contain C_7H_{16}, C_8H_{18} C_7H_8; Pennsylvania gasoline contains C_6H_{14}, C_7H_{16}, C_8H_{18}, cyclohexane, methyl-cyclohexane, traces of benzene; Borneo gasoline contains C_8H_{16}, C_8H_{20}, cyclohexane, cycloheptane, methylcyclohexane, methylcycloheptane; Esso gasoline contains C_5H_{12}, C_6H_{14}, C_6H_6, C_7H_8, cyclohexane, cycloheptane, methylcyclohexane, methylcycloheptane; Mesopotamian gasoline contains only saturated hydrocarbons, among which C_7H_{16} and $C_{10}H_{22}$ were identified.

Primary Thermal Decomposition. R. E. PAUL AND L. F. MARCK. *Ind Eng. Chem.* **26** (1934) pp. 454-58.

Propane, normal butane, and iso-butane were subjected to limited thermal dissociation in copper and fused silica tubes under conditions that permitted evaluation of the time of contact and the temperature, so that velocity constants of the primary thermal dissociation could be determined. The extent of the dissociation was measured by determining the olefin content of the product gases. Equations are given that represent variations of velocity constant with temperature for each of the three gases studied. Change of the surface-volume ratio of the apparatus, dilution with nitrogen, and change of the surface from copper to fused silica were found to have no effect under the experimental conditions used.

Sulfonic Acids from Petroleum. E. NEYMAN AND S. PILAT. *Ind. Eng. Chem.* **26** (1934) pp. 395-97.

The sulfonic acids obtained as by-products in petroleum refining have attracted increasing attention because of their use as fat splitting reagents and for emulsifying oils with aqueous solutions. One group of low molecular weight sulfonic acids gives water soluble calcium salts and another group of higher molecular weight insoluble calcium salts. The sources of the acids, their separation, and their properties that render them commercially useful are briefly described. A bibliography is appended.

The Synthesis of Lubricating Oils from Kogasin. FRANZ FISCHER AND HERBERT KOCH. *Brennstoff-Chem.* **14** (1933) pp. 463-68.

The olefin-containing gas-oil fraction,

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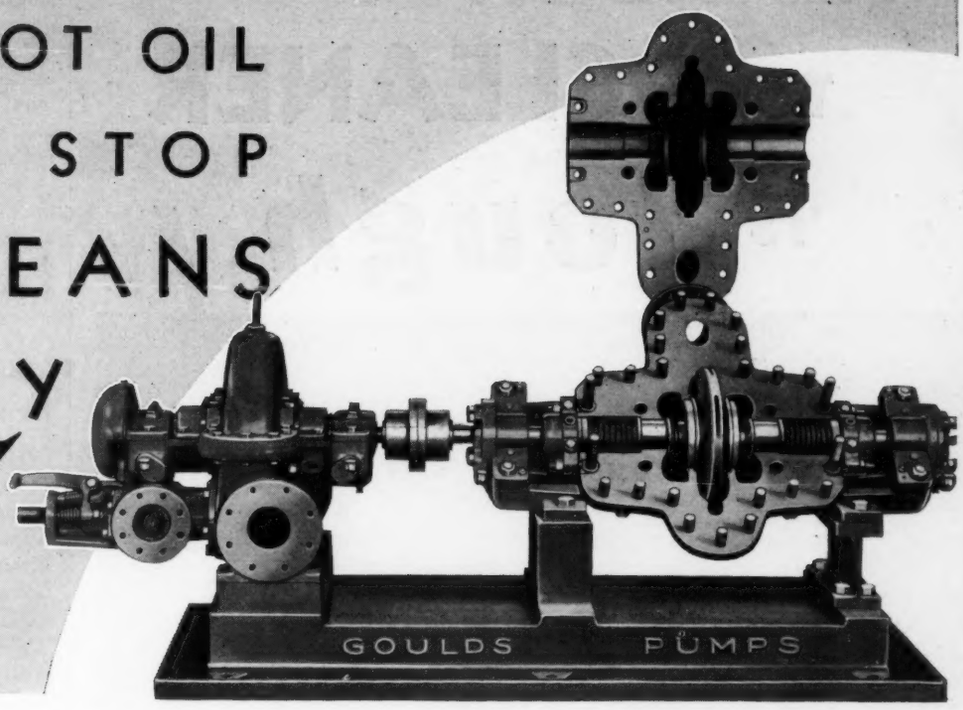
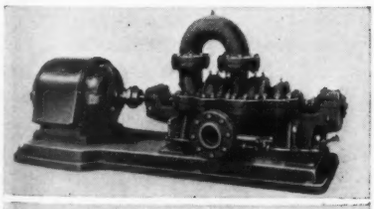
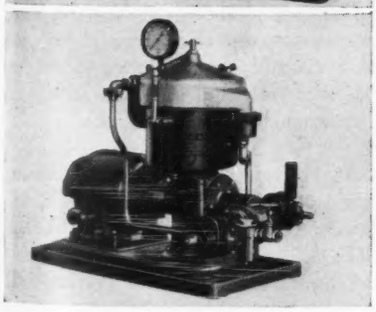


that is why most refineries prefer GOULDS





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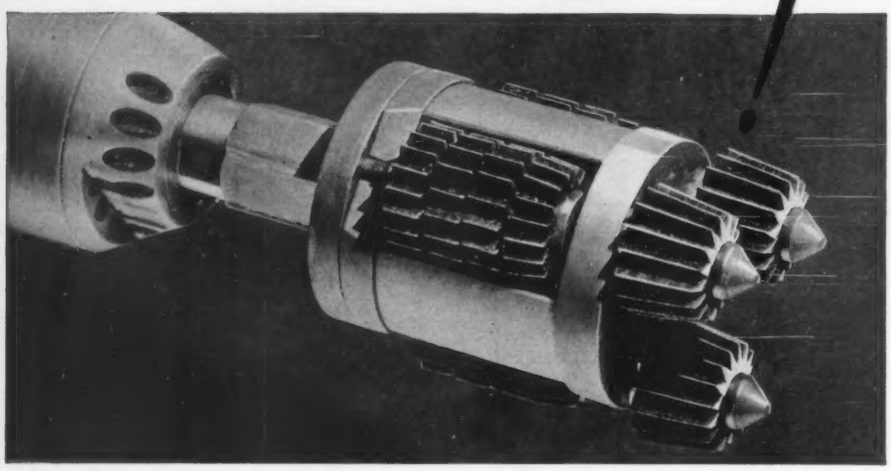

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known as Kogasin II, has been chlorinated with production of a series of chlorination products. These were condensed with a number of aromatic hydrocarbons by use of anhydrous aluminum chloride. The best yields were obtained with the tri- and tetrachloro compounds and xylene. The oils produced resembled naphthene-base oils in properties. Catalytic hydrogenation gives a water-white oil of low specific gravity, high stability against oxidation, and small carbon residue. The oil retains its lubricating value at low temperatures.

Manufacture: Processes and Plant

The Application of Physico-Chemical Principles to the Design of Liquid-Liquid Contact Equipment. Part II. Application of Phase-Rule Graphical Methods. T. G. HUNTER AND A. W. NASH. *Chem. & Ind.* **53** (1934) pp. 95-102T.

The three most important methods for bringing two liquid phases into contact in a solvent extraction process have been classified as follows: (1) single contact processes, (2) co-current multiple contact processes, (3) counter-current contact processes. In a previous paper the computations involved for the special case of equilibrium following the distribution law in a condensed ternary system consisting of two liquids and a solute was discussed in connection with each of the above contacting processes. Computations necessary for calculating equipment size and process results when equilibrium conditions are not in accordance with the distribution law are examined and described in the present paper. Many industrial extraction processes come within this classification. Among these are the solvent refining processes used for the treatment of petroleum oils.

Heat Transfer by Condensing Vapor on Vertical Tubes. C. G. KIRKBRIDE. *Ind. Eng. Chem.* **26** (1934) pp. 425-28.

The author believes that vertical tube condensers deserve more serious consideration than they have received in the past, partly because it is ordinarily more convenient to pull the bundles of horizontal tubes but also partly because heat transfer coefficients are not so well known for vertical tube devices. Data are presented on liquid films flowing down vertical walls. The data available in the literature for condensing vapors on vertical surfaces were correlated by means of chosen coordinates suggested by the Nusselt equation for the viscous flow of condensate films. Although the data of some investigators appear to check the

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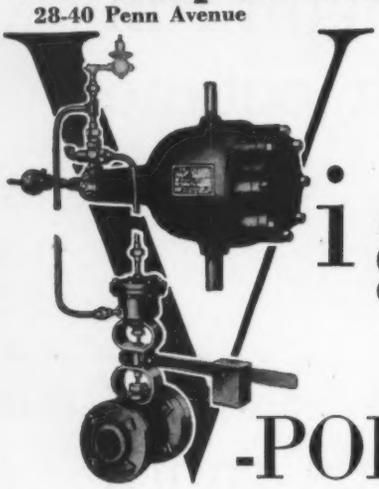

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Nusselt equation over a reasonable range; above this range the data indicate that the equation is no longer valid but gives results that are too low.

Steam-Film Heat Transfer Coefficients for Vertical Tubes. G. M. HEBBARD AND W. L. BADGER. *Ind. Eng. Chem.* **26** (1934) pp. 420-25.

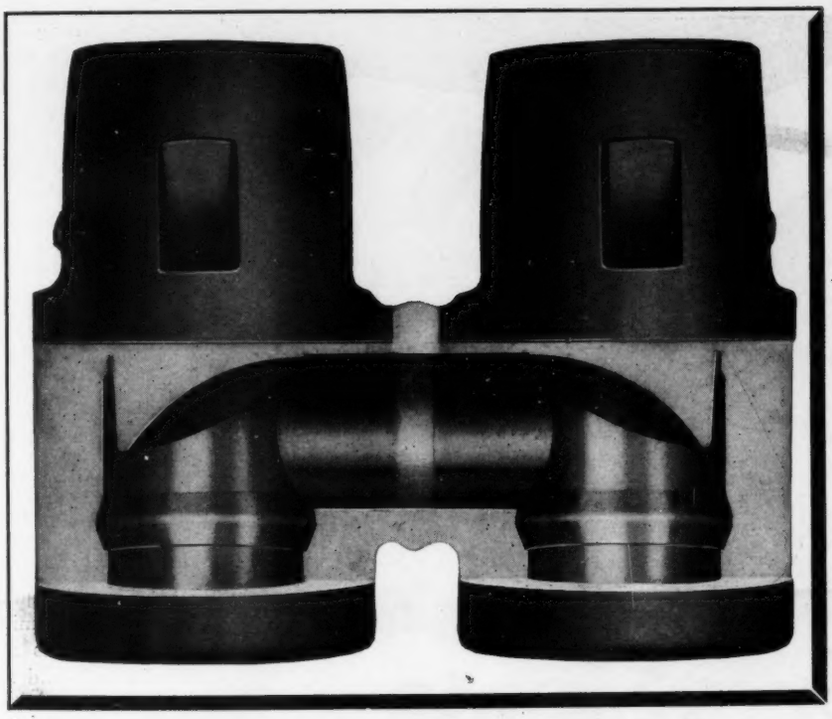
Measurements were made of the film coefficients of heat transfer for practically air-free steam condensing on the outside of a one-inch O. D. vertical tube 12 feet long, operated as a forced circulation evaporator. Tube-wall temperatures were measured. The coefficients obtained ranged from 900 to 1900 P.C.U. per hour per square foot per degree centigrade. Although these values appear somewhat low on account of the relatively great length of the tube employed, they actually average 33% higher than called for by the theoretical Nusselt equation.

Isothermal Flow of Liquid Layers. C. M. COOPER, T. B. DREW, AND W. H. MCADAMS. *Ind. Eng. Chem.* **26** (1934) pp. 428-32.

The use of vertical condensers and c wetted wall towers in connection wit such processes as adsorption, rectific tion, and humidification lends importance to the relationships that describe the motion of thin layers of liquid flowing under the action of gravity over wetted surfaces. From the data of six observers dealing with liquid flowing down wetted smooth walls of vertical towers or over flat plates it was concluded that the theoretical equation for steady isothermal stream-line flow applies for values of Reynold's numbers below 2100. For values greater than 2100 scattered data indicate that the Fanning equation, together with the friction factor curve for smooth circular pipes, may be used as an approximation. Data are not available for determining the possible effect of gas velocity upon the flow of a contiguous thin layer of liquid.

Calculation of Condensation with a Portion of the Condensate Layer in Turbulent Motion. A. P. COLBURN. *Ind. Eng. Chem.* **26** (1934) pp. 432-34.

The author attempts a more exact solution of the problem of film forming condensation on vertical tubes or surfaces based on the determination of an expression for the condensation rate at each point down the length of the vertical condenser and then an integration of the total condensation for the apparatus. The procedure is complicated for those cases in which the condensate layer becomes so thick near the lower end of the tube



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that a portion of it flows in turbulent motion. High vapor velocity in a downward direction will decrease the film thickness and increase the heat transfer coefficient. It may also cause a transition from viscous to turbulent flow. It is emphasized that the equations developed do not hold under conditions causing drop-forming condensation but from the available evidence film-forming condensation predominates with organic materials.

Heat Transfer in Jacketed Vessels. B. HEASTIE. *Ind. Chem.* **9,** (1933), p. 371.

Materials from which jacketed vessels are constructed are discussed, including glass lined vessels. Heat transfer between a surface and a boiling liquid is greater when the surface is vertical. Values of heat transfer coefficients to water and to a viscous liquid are given for vessels constructed of mild steel; mild steel, glass lined; stainless steel; mild steel, rubber lined; and mild steel, lead lined.

Extraction by Immiscible Solvents. T. W. EVANS. *Ind. Eng. Chem.* **26** (1934) pp. 439-40.

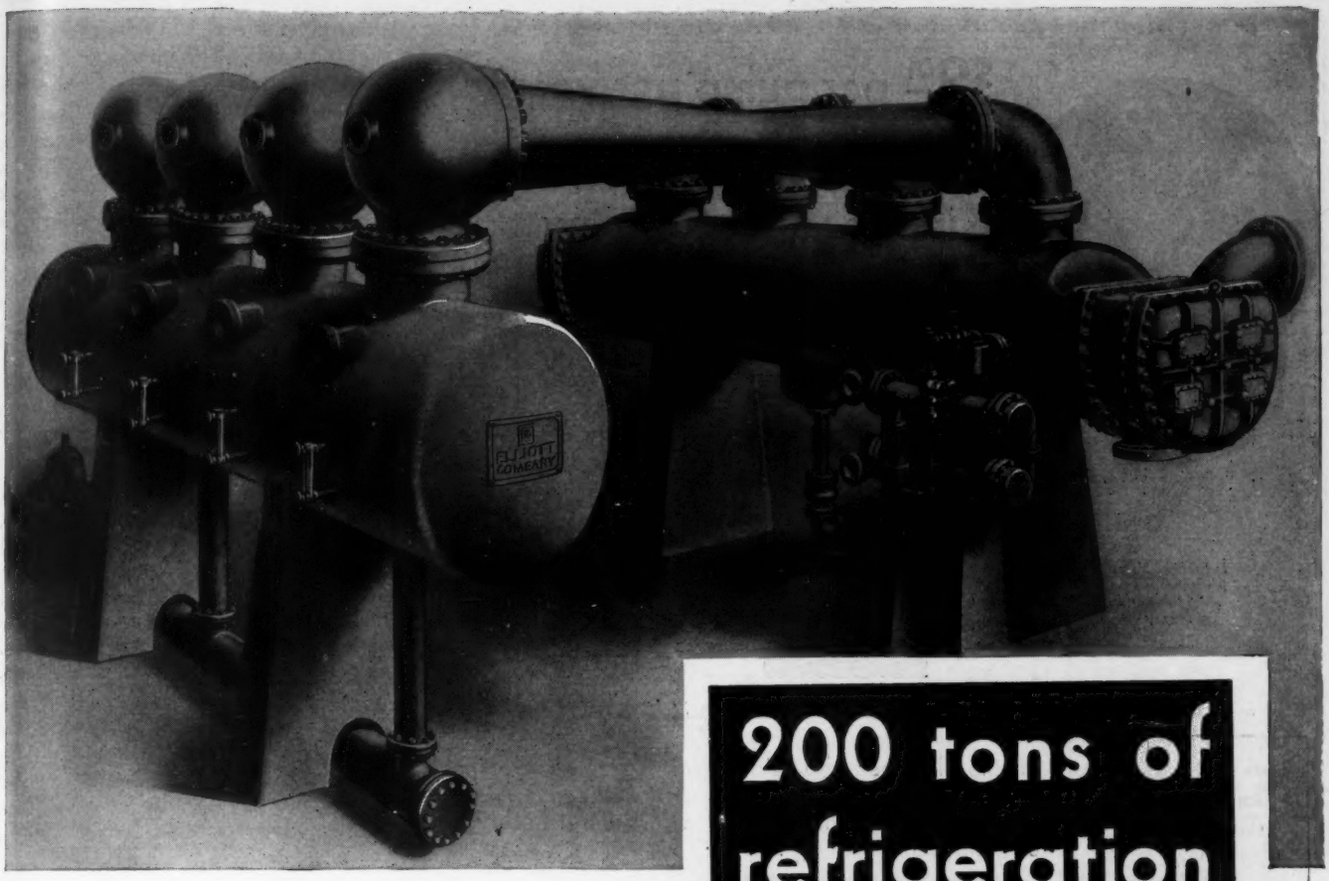
In the extraction of a solute by immiscible solvents, such that the partition law holds, the degree of solute removal is conditioned mainly by the relative volume of the solvents. Use of several small equal portions is better than one combined portion. Excessive sub-division is unjustified since a limiting percentage removal exists for every ratio of solvent volumes. At least 94% of this maximum removal of which a given volume of solvent is capable, is secured by division of the solvent into five portions and, therefore, in practice division into more than this number of portions is not worth while.

Amyl Alcohol from Pentanes. A. DOBRJANSKI, M. DAVYDOVA, AND E. MARGULES. *J. Appl. Chem, Russ.,* **6** (1933) pp. 1122-32.

Yields of 90% of amyl chloride are obtained by heating pentane-chlorine mixtures at 86-90° C. The production of di-chloropentane increases with increasing proportion of chlorine. Emulsions of amyl chloride stabilized by sodium oleate gave the highest yields (60-65%) of amyl alcohol when heated at 180-195° C. for one hour with 17-20% aqueous calcium hydroxide, sodium bicarbonate, or sodium carbonate. The unhydrolized portion loses chlorine and hydrogen, thus giving hydrochloric acid and amylene.

The Effect of Paraflow on Wax Crystallization and the Pour Point of Lubricating Oils. J. C. ZIMMER, G. H. B. DAVIS, AND P. K. FROLICH. *Penna. State Coll., Min. Ind. Expt. Sta., Bull.* **12** (1933) pp. 57-63.

Lubricating oils are congealed at fairly



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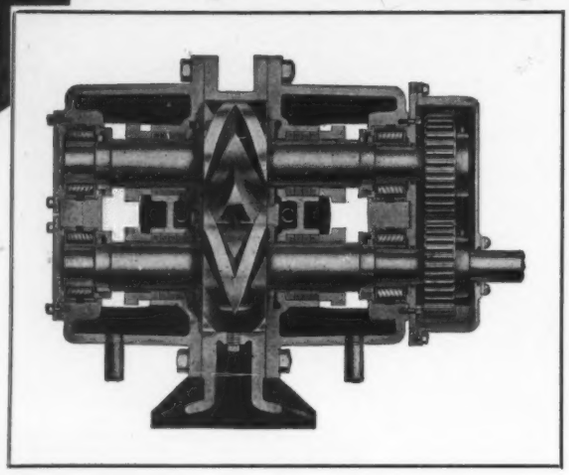

Interior View Kinney Type A Heliquad Pump

Years in Service	No. of Pumps	Total Years of Service
22	2	44
21	13	273
20	1	20
19	4	76
18	1	18
17	6	102
16	5	80
15	63	945
14	14	196
11	17	187
10	3	30
9	12	108
8	1	8
7	2	14
6	2	12
5	2	10
4	6	24
3	1	3
2	4	8
1	3	3
Total...	162	2,161

IF the old-timer who said "there are only two things you can be sure of—death and taxes" had run a refinery he might have added a few more! He might even have mentioned pumping costs.

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high temperatures by relatively small amounts of wax. The interlocking of the wax crystals that form prevent the free flow of the oil and the retention and adsorption of oil by the wax causes the mixture to set as a gel. Paraflow is preferentially adsorbed by wax, thus causing a reduction in the size of the crystals and preventing the adsorption of oil by the wax. The result is a mixture that flows freely at low temperatures even though the solid wax particles are suspended in the oil.

Choosing Gaskets for Use in Chemical Plants. JOHN H. PERRY. *Chem. & Met. Eng.* **41** (1934), pp. 194-98.

In every flange joint there are three essential elements: the flanges, the bolts, and the gaskets. Six types of flanged joints are pictured and discussed. Twenty commonly used types of formed and sized commercial gaskets are illustrated. The design rules used by many gasket manufacturers and engineers are given. The author emphasizes that thousands of dollars, thousands of unnecessary hours of shut-down and installation labor can be saved in a large plant each year by more careful selection of gasket materials. Two costs should be considered; not only to include the initial cost of the gaskets but the labor hours for renewals and the process hours lost due to gasket failure. A typical code and specification for gasket materials, as composed by McGeary, is included.

Power Consumption in Pumping Oil in Winter. ANON. *Erdol u. Teer.* **10** (1934) pp. 9-10.

The performance of three pumps handling cold oil was studied. The importance of the diameter of the suction pipe is emphasized. Results are tabulated, showing the time required to pump a liter of various oils at temperatures from 3° C. to 25° C. The time for pumping a liter at 3° C. for different oils varied from 14 to 132 seconds, and at 25° C. from 4.8 to 15.6 seconds.

Heating of Viscous Oils. MAY. *Erdol u. Teer,* **10** (1934) pp. 8-9.

The storage of low pour-point oils is considered. Important factors in the design of heating coils for tanks are the material of which the coil is made, the temperature of the steam, and the rate of throughput of steam. All steam should be condensed in the coil. A source of loss is the heat loss from the sides of the tank during heating. An internal coil heater, placed in a conical hood-shaped vessel occupying part of the floor of the tank, is described. The top of the hood is closed by a valve which controls the flow of oil into the hood. Using this device only the oil to be re-

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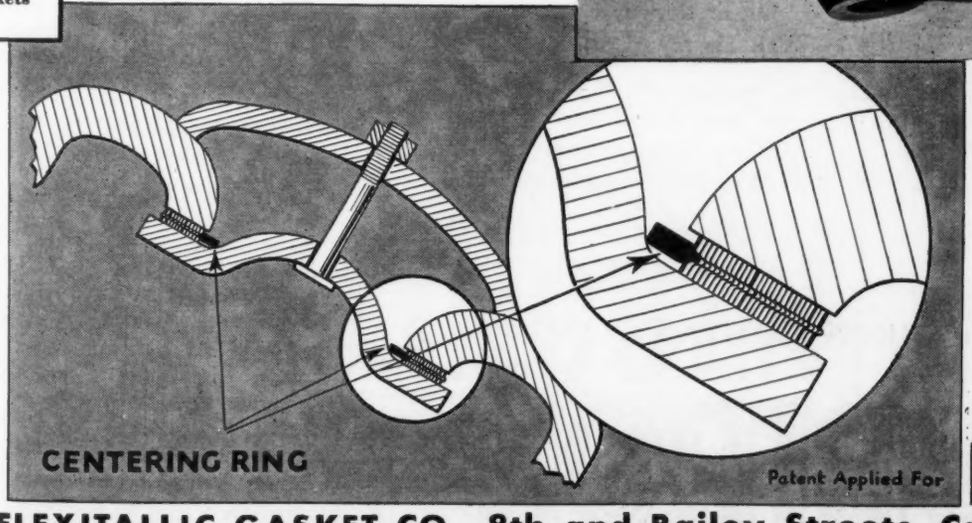

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moved can be heated, thus avoiding waste of heat.

Products: Properties and Utilization

Performance Tests of Alcohol-gasoline Fuel Blends. R. B. GRAY. *Agr. Eng.* **14** (1933), p. 185.

The octane ratings of three gasolines averaged 66.6 whereas blends containing 10, 20, and 30% of absolute alcohol had octane ratings respectively of 74, 79.6, and 84.6. When used in lightly or unloaded trucks slightly higher mileages were obtained from the straight gasoline than from the 20% alcohol blend. However, with heavily loaded trucks the carbon accumulation is greater with the straight gasoline. When tested in a four-cylinder tractor fitted with high-altitude pistons, the maximum horsepower increased from 30 to 44.4 when a 30% alcohol blend was used rather than straight gasoline. The 20% alcohol blend gave better fuel economy than straight gasoline. A two-cylinder horizontal tractor engine developed 31.7 horsepower on straight gasoline and 32.2 with a 10% alcohol blend.

Diethyl Peroxide as a Pro-knock. A. EGERTON AND A. R. UBBELOHDE. *Nature* **133** (1934), p. 179.

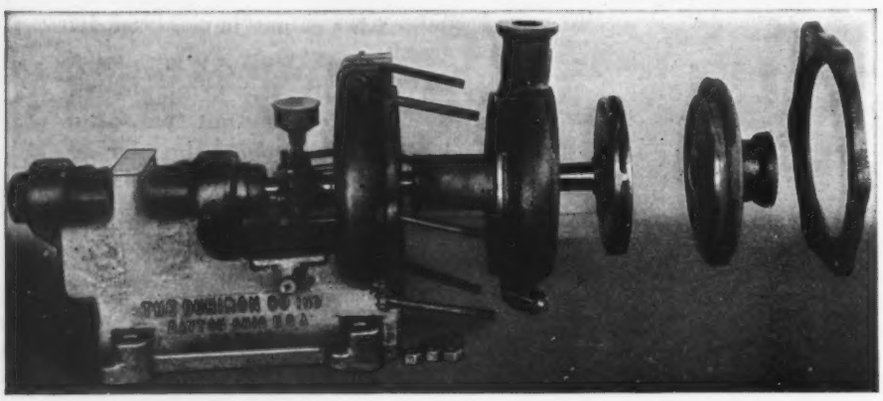
Diethyl peroxide is a violent pro-knock compound slightly more powerful than amyl nitrite. Its action is inhibited by tetra ethyl lead. Ethyl hydrogen peroxide was also found to be definitely a pro-knock compound, and also hydrogen peroxide has a definite, though slight, pro-knock tendency.

Chemical Significance of Tendency to Smoke. S. T. MINCHIN. *Proc. World Petr. Congr.* **2** (1933) p. 738.

The physical and chemical factors governing the combustion of kerosene in wick-fed lamps are outlined. The smoke point test is discussed with reference to its value in relation to the refining problems and to the effect on it of the chemical combustion of the fuel. A series of tests on the effect of draught in the lamp is reported. The greater the draught for a given set of other conditions, the smaller the fuel consumption, the smaller the flame, and the greater the luminosity. A table is given showing the variation in electrical resistance of kerosene flame with variations in heights about the flame base. It is shown that the particles get larger and the resistance lower as the flame is ascended. At the smoking tip of a flame glowing particles escape as non-luminous particles. Smoking is attributed, therefore, to the coagulation of particles too large to be burned under existent conditions. The effect of chemical composition on the smoke point is discussed and an empirical relationship is developed permitting calculation of the smoke point for different kerosenes. All hydrocarbons examined were found to conform to this equation. In the paraffin series flame height decreases with increase in molecular weight but in the naphthene, aromatic, and unsaturated series the flame height increases. The use of the smoke point in determining the most suitable cuts of a given crude oil is explained.

Recent Researches in Lubrication. J. E. SOUTHCOMBE. *Oil & Col. Trades J.*, (1934) **85**, pp. 320-21.

A film thickness greater than 0.001 millimeter is necessary before boundary conditions are eliminated. Conditions leading to boundary film lubrication are reciprocating motions where the parts come to rest, rocking motions of pins, and linkages, and high temperature conditions that lead to viscosity reduced below the limit required for film formation and maintenance. Work from the literature is quoted in which it is stated that the force field of a solid is transmitted



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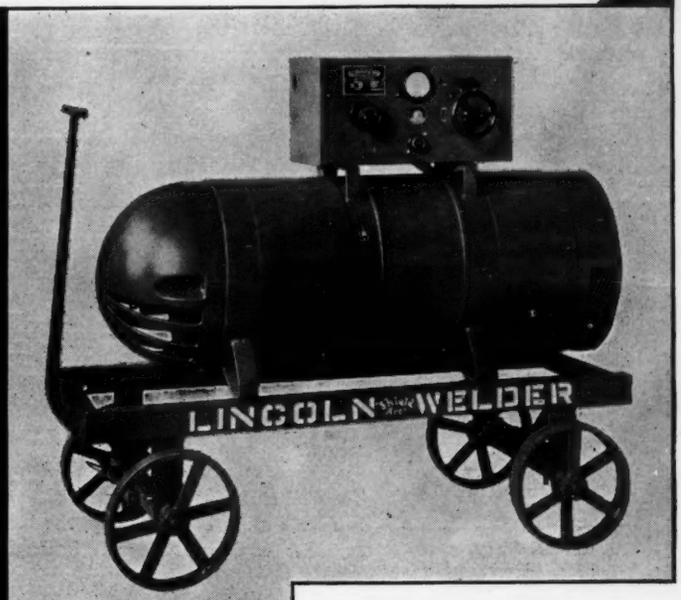

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through thin films 100 molecules or more in thickness, and that good boundary lubricants are poor adhesives. This is considered to support the multi-molecular layer theory of adsorbed lubricating films. Brief consideration is given to the effect of time, temperature and atmosphere upon the boundary layer.

Significance of Fillers in Bituminous Coating Materials. R. WILHELMI. *Erdol u. Teer,* 10, (1934), pp. 20-22, 32-33.

Inorganic or organic materials are usually added to bitumen for use in paints or filling compounds. The sole object is not to cheapen the mixture but the filler has a definite influence on the properties of the material. Fillers hinder the flow of bitumen when the surface becomes hot. The stiffening effect depends upon fineness and on the capillary properties of the filler. The finer the particles, the greater the effect. German railway specifications call for material passing a 1600 mesh per sq. cm. sieve and not more than 10% retained on a 10,000 mesh sieve. The effect of filler increases up to about 30% by volume and above a certain figure in each instance the bitumen is insufficient to saturate the filler. Irregular-shaped filler grains are better than spherical or cubical particles. Fillers improve the adhesive properties and resistance to tearing and bending of bituminous paints. The ductility of mixtures at low temperatures is improved more by fillers, such as quartz or chalk, than by strongly absorbing fillers, such as bauxite. Fillers of fibrous structure, such as asbestos, have a favorable influence on resistance to bending.

The Life of Impregnated Paper, J. B. WHITEHEAD. *Elec. Eng.* 53 (1934) pp. 244-51.

Fourteen different oils used for the impregnation of one grade of cable insulating paper were studied by means of accelerated life tests. When using oils of a definite type the life of the paper increases with penetrative power. The effect of di-electric loss on life is negligible. Complete absence of gaseous ionization was effected and a definite relationship found between the life of impregnated paper under stress and the capillary constant of the oil.

Exhaust Gas Analyser. *Auto. Eng.,* 24 (1934), p. 28.

The instrument is based upon the principle that a wire passing an electrical current exists at a temperature depending upon the thermal conductivity of the gaseous medium surrounding it, when convection and radiation are reduced to a minimum. The wire is made one arm of a Wheatstone bridge, and a similar wire surrounded by a standard gas, for example saturated air, is the other arm. Conditions are so arranged that with air surrounding the analyzing wire, the galvanometer shows zero deflection. The introduction of exhaust gas disturbs the balance because the cooling rates of the wires are such as to alter their resistances. The tester is calibrated to show air-fuel ratio over the range 10 to 15, since it has been determined that a linear relationship exists between thermal conductivity and air-fuel ratio.

Examination of the Effects of Cold on Oils. P. WOOG. *Proc. World Petr. Congr.,* 2 (1933), p. 412.

A method of determining cold tests is described. The apparatus comprises a long rod, at the bottom of which is a perforated plate resting on the congealed sample. The entire assembly is surrounded by suitable cooling jackets, e.g., acetone and solid carbon dioxide. The rod is insulated so as to allow the taking of an automatic electrical record of the downward movement of the plate and rod at the set point. Results obtained with the apparatus are presented in tabular and graphical form.

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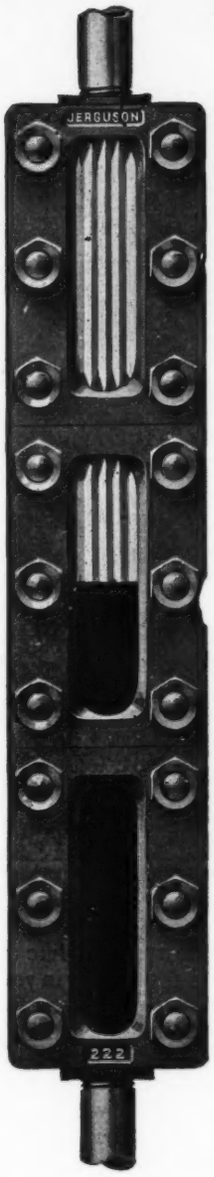

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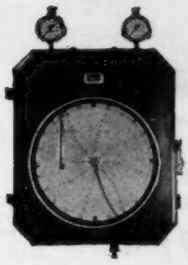

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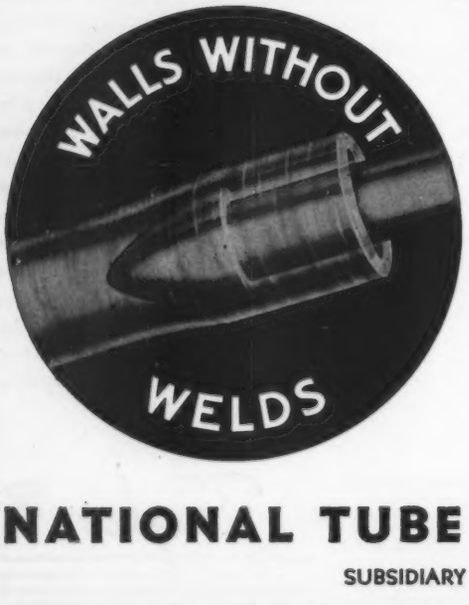

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Natural Gasoline Convention Considers Economic Condition

THE Natural Gasoline Association of America, at its annual convention in Tulsa, May 9-11, devoted its sessions to a study of economic problems affecting the industry, the petroleum code and the natural gasoline industry, the problem of wider utilization of its products, and the technology of gasoline manufacture.

In the absence of Frank L. Chase, Lone Star Gas Company, who has welcomed the gasoline conventions for many years, A. V. Borque, secretary, Western Petroleum Refiners Association, and past secretary of the National Gasoline Association, gave the welcoming address. Mr. Borque interestingly reviewed the history of the association, giving many interesting side-

WILLIAM F. LOWE

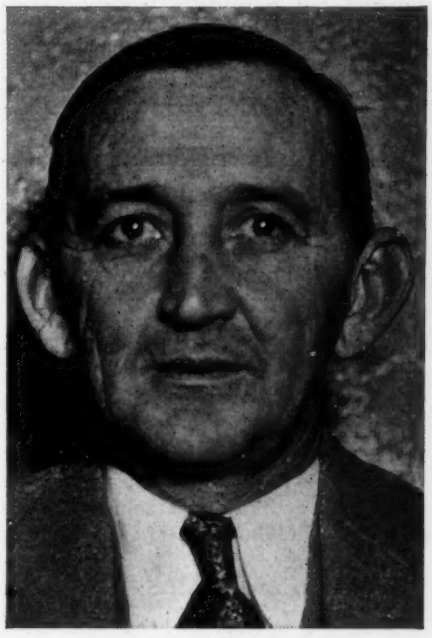
lights on its early meetings, pleasantly discussing both men and methods. He stated that although much progress had been made in the matter of selling the refiners on the value and application of natural gasoline in motor fuels, the present day problems of the natural gasoline industry were still chiefly those of obtaining a price upon which profitable operations could be carried out, and of procuring still wider usage of natural gasoline by the refining industry.

D. C. Williams, Continental Oil Company, and president of the association in his address discussed the price problem and quantity of consumption of naturals, and the natural gasoline industry's part in the petroleum code. Mr. Williams stated that the production of natural gasoline is roughly 100,000 barrels daily, and of this amount approximately 50 percent is produced in the Mid-Continent district. He stated the industry consists of about 900 plants owned by around 200 operators. The integrated companies produce about 65 percent of the total production, with the utility companies and non-integrated concerns producing the remaining 35 percent. Mr. Williams stated that the natural gasoline plant performs a conservation function of real importance, in the extraction of natural gasoline from gas.

Such an important function can not be overlooked, and must be supported.

It was the general concensus of opinion at the convention that some steps must be taken to assure the industry a range of prices for its products which will assure profitable operation. Natural gasoline prices during recent months have not been satisfactory, especially in view of mounting costs of operation through increases in number of employes, and because of increasing costs of materials and supplies. Several operators have expressed the determination to invest in storage facilities of such type as 50,000-barrel tankage to be provided for the purpose of storing natural gasoline during periods where very low prices prevail. The industry, however, is confronted with the problem of inability to store its raw material, gas—which must be processed continually as received, and also the difficult problem of storing its highly volatile finished product. Despite this latter difficulty, however, it is expected that more and more operators will follow the lead of several larger concerns, and provide modern efficient storage facilities for natural gasoline.

THE natural gasoline industry gained recognition on the Planning and Coordination Committee through the formation of the Natural Gasoline Sub-Committee May 25. Its personnel is Charles F. F. Roeser, Roeser & Pendleton, Fort Worth, chairman; William F. Lowe, secretary of the Natural Gasoline Association of America, Tulsa, vice chairman; J. B. Atkins, Parade Gasoline Company, Tulsa; R. E. Beckley, Standard Gasoline Company, Los Angeles; O. C. Feld, O. C. Field Gasoline Company, Los Angeles; L. Fitzpatrick, Ohio Oil Company, Findlay; Ray E. Miller, Hanlon-Buchanan, Inc., Tulsa; R. N. Parks, Virginian Gas & Gasoline Company, Charleston, West Virginia; F. E. Rice, Phillips Petroleum Company, Bartlesville; and A. T. Scherer, Sinclair Prairie Oil Company, Tulsa.



D. C. WILLIAMS

The Planning and Coordination Committee will ask refiners to purchase the surplus supply of natural gasoline. A joint committee of refiners and natural gasoline manufacturers will be formed to work in behalf of stabilization of the industry and to enlarge the market for this product.

Williams Again Heads Natural Gasoline Body

D. C WILLIAMS, Continental Oil Company, was reelected president of the Natural Gasoline Association, and the following vice presidents were elected: R. C. Wheeler, General Petroleum Corporation; W. E. Reardon, Columbian Gasoline Corporation, and

John B. Atkins, Parade Gasoline Company.

The following concerns to name directors for the two-year term beginning 1934 were: Amerada Petroleum Corporation, Columbia Gasoline Corporation, Hanlon-Buchanan, Inc., Kansas Gas & Gasoline Company, Parade Gasoline Company, Skelly Oil Company, Phillips Petroleum Company, Sinclair Prairie Oil Company, Standard Oil Company of California, Warren Petroleum Company, and L. W. Wentz, Oil Division.

Directors whose terms do not expire until 1935 are as follows: Carbide & Carbon Chemicals Corporation, Continental Oil Company, J. E. Crosbie, Inc., Empire Oil & Refining Company, O. C. Field Gasoline Company, General Petroleum Corporation, Lone Star Gasoline Company, Roeser & Pendleton, Inc., Shell Petroleum Corporation and Texas Pacific Coal & Oil Company.

The Natural Gasoline Supply Men's Association at its annual meeting the morning of May 9 with B. W. Vinson, president, presiding, increased its directorate from eight to nine, and elected four new directors. The new directors include the following: M. F. Waters, Hanlon-Waters Company; E. H. Triphouse, Taylor Instrument Companies; M. H. Kotzebue, Tulsa Boiler & Machinery Corporation; and J. A. Lupfer, Worthington Machinery Corporation of Oklahoma. Those directors re-elected were Paul Raigorodsky, Petroleum Engineering, Inc.; G. B. Lane, The Foxboro Company; W. D. Moore, The Moorlane Company; B. W. Vinson, B. W. Vinson Company, Inc., and J. H. Satterwhite, Westcott & Greis, Inc. W. F. Lowe, newly elected secretary of the Natural Gasoline Association of America, becomes also, secretary of the Natural Gasoline Supply Men's Association. This year, as heretofore, the supply group provided the daily luncheons for those in attendance at the convention, the annual dance and annual smoker.

Rodgers Appointed Chairman Regional District No. 1

W. S. S. Rodgers, president of The Texas Company has been appointed Chairman of the Refining Committee in Regional District No. 1 to succeed F. R. Coates, Cities Service Company, who has resigned as chairman of the refining committee to accept an appointment as a member of the Planning and Coordination Committee in Washington.

The following have been added to the membership of the refining committee of Regional District No. 1:

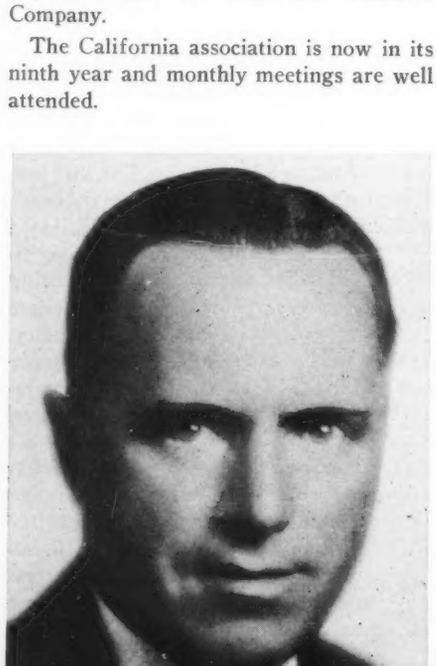
W. W. Lowe, Cities Service Company, and G. H. Van Senden, Shell Union Oil Corporation.

The membership of the refining committee is now as follows: W. S. S. Rodgers, The Texas Company, chairman; G. H. Taber, Jr., Sinclair Refining Company, vice chairman; Chas. B. Buerger, Gulf Refining Company; Wilbur Burt, Standard Oil Company of New York; W. M. Irish, The Atlantic Refining Company; Otto Koch, Kendall Refining Company; H. A. Logan, United Refining Company; W. W. Lowe, Cities Service Company; Sam Messer, Quaker State Oil Refining Corporation; A. E. Pew, Jr., Sun Oil Company; Noel Robinson, Tide Water Associated Oil Company; Chester Smith, Standard Oil Company of New Jersey; C. L. Suhr, Pennzoil Company; G. H. Van Senden, Shell Union Oil Corporation.

Eggleston Heads California Body

HERBERT L. EGGLESTON, refinery manager for the Gilmore Oil Company, has been elected president of California Natural Gasoline Association by mail ballot and assumed his duties on June 1. He served as vice president the past year and is a charter member of the association. Tom L. Taggart was elected vice president and is also a charter member of the organization. He is contract superintendent of Standard Gasoline Company.

The California association is now in its ninth year and monthly meetings are well attended.



HERBERT L. EGGLESTON

Gasoline Allocation Board Named

APPOINTMENT of allocators, committees and agencies to make allocations under Section 3 of the new refinery article of the oil code has been announced by the Planning and Coordination Committee, as follows:

Districts 1 and 2: Committee: W. S. S. Rodgers, chairman; George H. Tabor, W. M. Irish, W. W. Lowe, Charles Buerger, Otto Koch, C. L. Suhr, Sam Messer, G. H. Van Senden, Wilbur Burt, Chester Smith, A. E. Pew, Jr., Noel Robinson, H. A. Logan and C. B. Watson; no allocator.

District 3: Morrison Griffith, allocator; no agency.

District 4: Committee: C. W. Boggs, chairman; Walter Miller, E. C. Marshall, L. B. Simms and H. W. Camp; no allocator.

District 5-a: Dr. E. R. Lederer, allocator; agency: Roy B. Jones, B. P. Crittenden, T. M. Potter, K. W. Bartlett, R. G. McIntyre, W. D. Richardson, H. B. May, L. F. Sinclair, L. W. Barbour, W. F. Anderson, J. M. Sands and Chester Slimp.

District 5-b: Committee: E. E. Plumly, chairman; W. C. Soullin, R. B. High, Stuart A. Giraud, D. W. Hovey, P. Kendall, H. S. Lane, W. M. Averill, W. A. Slater, P. J. Sweeny, Craig Cullinan and R. R. Russell; no allocator.

District 6-a: Agency: H. H. Hewetson, chairman; R. B. High, Don Smith, D. B. Williams, secretary; J. T. Cochrane; no allocator.

District 6-b: Committee: T. H. Barton, chairman; George Fox, D. W. Harris, S. M. Patterson, Horace Canon, F. R. Schneider, B. H. Gray, F. O. Prior, W. B. Hassett, C. L. Crenshaw; allocator: J. K. Mahony.

District 7: Committee: T. A. Dines, chairman; R. E. Beard, James Fenex, P. N. Fortin, J. W. Glass, C. W. Hart, B. C. Holt, James W. Johnson, L. M. Johnson, L. F. H. Wiling, Henry D. Moyle, William Rice, H. H. Schwartz and Paul Stock; no allocator.

District 8: Committee: C. E. Olmsted, chairman; A. E. McLaughlin, secretary; L. A. Barnason, L. F. Bayer, L. F. Bushnell, S. J. Dickey, W. J. Reid, W. L. Stewart, Jr.; Charles Drador, C. B. Edington, Arthur M. Kelly, A. E. Lacomble, R. S. MacMillan, W. H. Morgan, A. S. Russell and L. H. Johnson; no allocator.

In districts where no allocator has been appointed, the committee or agency will act as allocator.

Board Established for Refinery Controversies

ESTABLISHMENT of a board of review to pass upon controversies affecting refinery operations under the oil code was announced June 2 by Oil Administrator Harold L. Ickes.

The board, nominated by the Planning and Coordination Committee, will consist of W. R. Boyd, New York, chairman; C. B. Watson, Chicago; P. M. Miskell, Tulsa, and A. C. McLaughlin, Los Angeles.

Decisions of the board will not necessarily be final and appeals may be taken to the administrator, as provided in the revised refinery section of the code.

Cracking Conference Visits Texas Plants

THE sixth regular meeting of the Cracking Development Conference occupied a four-day session ending May 11 and centered in Texas with Port Arthur as starting point. From Port Arthur the conference moved on to Houston, Texas City, and Baytown. The itinerary was arranged with a view to the opportunity for inspection of new technical features in plant design, particularly the new combination type cracking plants. Previous meetings of the Cracking Development Conference, which is attended by petroleum technologists and executive representatives of a group of companies, have been held at New York and at Whiting, Indiana, in addition to Port Arthur. The next meeting will be held at Bayway, New Jersey, where the Standard Oil Company groups will be host to the gathering.

Participating companies are the Gasoline Products Company, The M. W. Kellogg Company, The Texas Company, Standard Oil Company (Indiana), and Standard Oil Company of New Jersey. William F. Moore, vice president and general manager of Gasoline Products Company, who presided at the recent meeting, is permanent chairman of the Cracking Development Conference.

Plants visited in connection with the conference just held included, that of The Texas Company, at Port Arthur, Pan American Refining Company at Texas City, and Humble Oil & Refining Company at Baytown. Each day's activities were so scheduled as to provide adequate time for discussion of each topic. In the evening, on May 10, The Texas Company was host at a dinner for the conference in Galveston, and on May 11, following the Baytown inspection, Humble Oil & Refining Company entertained the conference at San Jacinto Inn, which is located at San Jacinto battle field near Houston.

The object of the Cracking Development Conference is to correlate experimental and plant development work in pyrolytic cracking which is carried on in the laboratories and refineries of the participating companies. It serves as a clearing house for improvements in processing methods and acts as a committee on standards used in the design of equipment. Improvements favorably passed are incorporated by The M. W. Kellogg Company, as engineers and licensing agents, in new designs and in the remodeling of present cracking equipment of licensees of Gasoline Products Company. In addition to its licensing function, Gasoline Products Company is concerned with the furtherance and coordination of research and development from the standpoint of process and equipment. As is reflected in the program of the meeting just held, the Cracking Development Conference is organized according to three principal functions—cracking plant operation, engineering and design, and research. In addition to the general conference, a committee on research, of which J. T. Ward, research director of The M. W. Kellogg Company, is chairman, now conducts additional intermediate meetings.

Topics discussed included the following: Design Data for Naphtha Reforming Equipment; Reforming Operations as Conducted in Typical Refineries of Latest Design; Design, Features, and Operation of New Cracking Units, Including the Largest Recently Installed; Heat Balance Data on Specific deFlorez Units; General Performance of Installed Cracking Equipment at Various Plants, Including Prospective Modifications for Improvement; Reduced Crude Cracking Operations; deFlorez Units and Pressure Coke Still Operations; Soaking Drum Liquid Level Indication and Control; Design and Use of Blowdown Systems; Specific Experience on Combination Unit Operations in Plants of Varying Capacity; Vis-Breaking and Cracking Experiments; Vapor Phase Unit Operations; Cost of Cracked Gasoline from Mid-Continent Crude by Single Pass Cracking; Cracking Light Coastal and Light Paraffine Stocks at Various Soaker Pressures; Effect of Distillate Endpoint on Results of Cracking West Texas Gas Oil; Effect of Cycle Gas Oil Withdrawal on Yields and Production Cost.

Equipment design, and operation embraced many topics for discussion, including the following: Use of Cast Iron in Refinery Construction, Temperatures of Tubes and Vessels in Service, the Effect of Elevated Temperatures on Allowable Stresses, Corrosion Protection, Welding Low Chrome Tubing, Specifications for Oil and Vapor Line Tubing, Comparison of Trays and Baffles for Fractionation, Packing Hot Oil Pumps, Use of Welded Heater Tubes, Gas Engine Drive for Hot Oil Pumps, Economics of Heater Construction, Pressure Drops Through Heater and Lines.

Socony-Vacuum Changes Name

STOCKHOLDERS of Socony-Vacuum Corporation voted in annual meeting to change the name of the company to Socony-Vacuum Oil Company, Incorporated, and approved a reduction of the par value of the capital stock from $25 to $15 per share and the writing off against the capital surplus thus made available of an item in the balance sheet of $228,123,580.68 of good-will and appreciation of properties, including trade-marks and trade-names. This item resulted from the acquisition of other companies by Socony-Vacuum Corporation during the past several years, in which by exchange of stock the company acquired intangible assets such as trade-marks, trade-names, licenses, etc., and tangible assets carried on the books of the selling companies at the time of sale.

Directors re-elected are: Charles E. Arnott, Edwy R. Brown, John A. Brown, Arthur F. Corwin, Frederic Ewing, Frederick S. Fales, George V. Holton, Charles L. Jones, Herbert L. Pratt, Harold F. Sheets, Richard P. Tinsley.

At a meeting of the directors, the following officers were re-elected: Herbert L. Pratt, chairman of the board, Charles E. Arnott, president, John A. Brown, chairman of the executive committee, and Richard P. Tinsley, secretary and treasurer.

Merger of Companies In Far East Explained

Motives behind the merger in the Far East of Standard Oil Company of New Jersey, subsidiaries and Socony-Vacuum subsidiaries are explained in the annual statement of the Standard Oil Company of New Jersey recently received. The statement says:

"For some time there had been recognized the economic advantage of uniting the marketing facilities of Socony-Vacuum Corporation in the Far East with the producing and refining facilities of subsidiaries of Standard Oil Company of New Jersey in the same area.

"Socony-Vacuum, either directly or through locally organized subsidiary or affiliated companies, owned storage and distributing facilities and maintained a marketing organization in every important market of the Far

East. However, it had no producing properties or refining facilities.

"On the other hand, while Standard Oil Company of New Jersey interests had not distributing facilities in that part of the world, its Dutch subsidiary, The Coloniale, owned large proven crude oil reserves and modern refining facilities in the Netherlands East Indies.

"Hence the business of the two companies in this territory was truly complimentary, making their union a normal and logical business step to meet the particular needs of the two companies.

"Negotiations to that end culminated in an agreement to combine the businesses, properties and assets, lying principally in India, China, Japan, South Africa, Dutch East Indies, Australia and New Zealand. There was organized in Delaware the Standard-Vacuum Oil Company, to which were transferred the respective interests of the companies in the agreement.

"All of the new company's capital stock was issued to Socony-Vacuum and Standard Oil Company of New Jersey in equal amounts. The new company is a balanced and fully integrated unit, possessing crude supplies and refineries advantageously located, established marketing outlets, storage and distributing facilities, an experienced marketing organization and adequate capital resources."

Whiting Refinery Personnel Changes

DR. O. E. BRANSKY, manager of Standard Oil Company (Indiana) Whiting refinery, has been appointed assistant general manager of manufacturing at the Chicago office, it was announced by Edward G. Seubert, president of the company. Dr. E. J. Shaeffer, general superintendent of the refinery, succeeds Dr. Bransky as manager at Whiting.

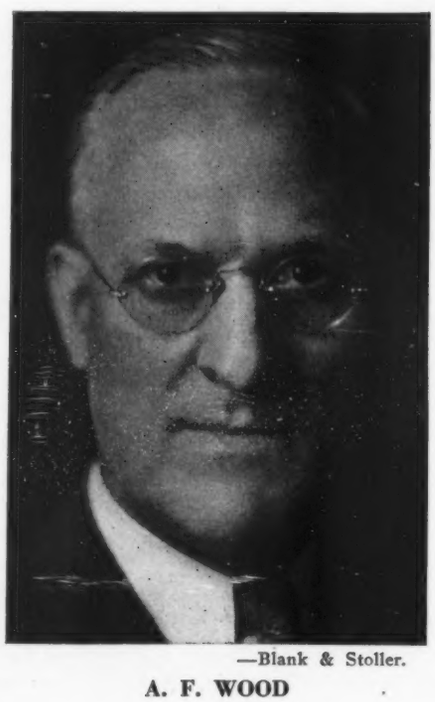
Other changes in Whiting executive personnel were announced. F. D. Rexwinkle, assistant general superintendent, succeeds Dr. Shaeffer as general superintendent, and Dr. R. T. Myrick, head of the light oils department, assumes the position vacated by Mr. Rexwinkle as assistant general superintendent.

A leader in Whiting civic affairs, Dr. Bransky will continue to reside in his home at 1748 Central Avenue in that city. He is a member of the Whiting and East Chicago Chambers of Commerce, a member of the Whiting board of education, one of the board of managers of the Whiting Community Service, and a director of the State Bank of Whiting. He has been a resident of Whiting since 1910, when he joined Standard Oil Company after receiving his Ph. D. from Johns Hopkins University. After four years working as a research chemist, he assumed duties in the medicinal white oil department, and later served as head of the paraffin department. In 1931 he was promoted to the position of manager of the refinery.

The new manager of the refinery, Dr. Shaeffer, also is active in community affairs, being a member of the Whiting and Robertsdale, as well as the East Chicago Chambers of Commerce, and of the Whiting Relief and Aid Society. Whiting has been his home since 1915, when he joined the company as a chemist. In 1913 re received his Ph. D. from Johns Hopkins, after which he served as Carnegie research fellow until coming to Whiting. After several years as superintendent of the light oils department, he became in 1927 assistant general superintendent of the refinery, and in 1931 was made general superintendent, the position he has just vacated to become manager.

Mr. Rexwinkle, who succeeds Dr. Shaeffer as general superintendent, came to Whiting refinery in 1916 as draftsman, and is active in the community's civic affairs, being a member of the Whiting Chamber of Commerce as well as of the City Planning Committee. In 1921 he became assistant superintendent of the paraffin department, four years later was made superintendent of that department, and in 1929 was promoted to assistant general superintendent.

Dr. Myrick went to Whiting in 1916, working as a chemist in the laboratory until 1920, when he became assistant superintendent of the acid works. He later worked in the finishing department and then in the tower and crude stills, of which he was made foreman in 1927. Two years later he was promoted to superintendent of the light oils department, the position he has just left to become assistant general superintendent.



—Blank & Stoller.

A. F. WOOD

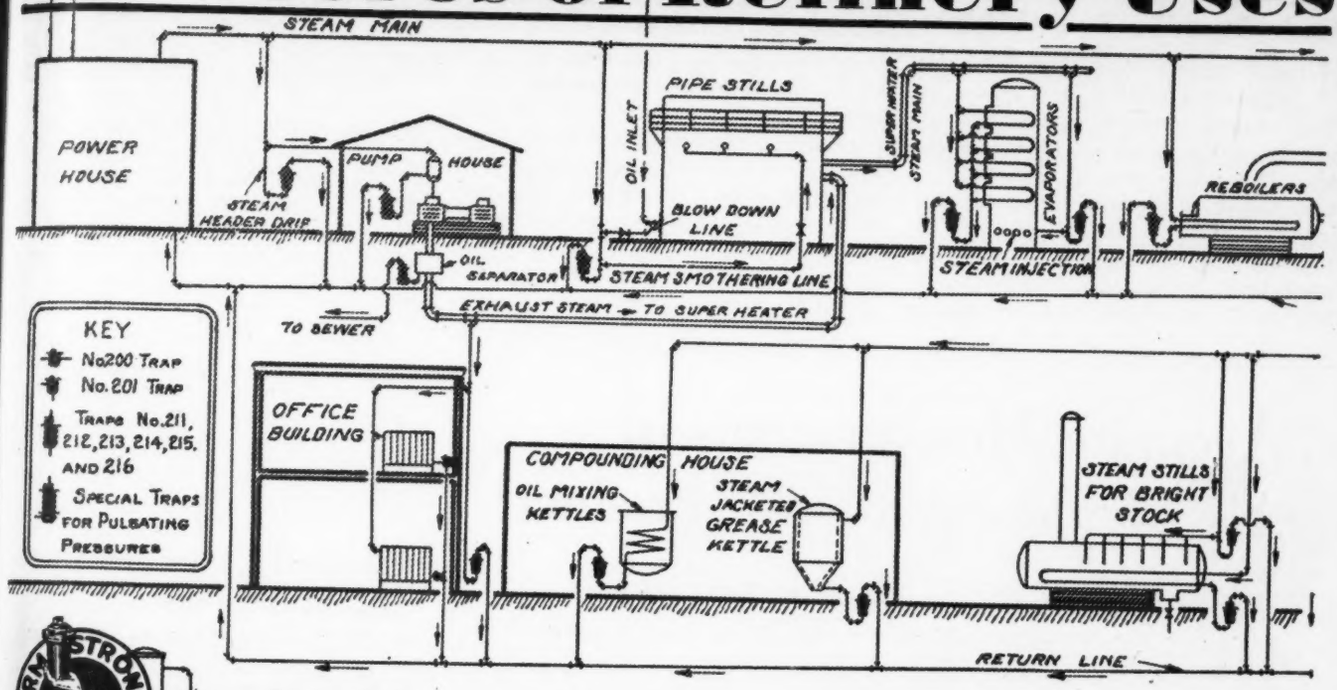
New Natural Gasoline Company Organized

ANNOUNCEMENT has been made of the organization of the Wood-Moore Corporation by A. F. Wood formerly vice president and sales manager of Hanlon-Buchanan, Inc., and Dale W. Moore, president of the Dale W. Moore Oil Company. The new company, which will have offices on the fourth floor of the Philtower Building, Tulsa, Oklahoma, will engage in the manufacture and marketing of natural gasoline. Wood, who will be president of the new company, has been active in the natural gasoline industry for 17 years, having started with Chestnut and Smith Corporation in 1917. He resigned as sales manager of that company in 1929 to become associated with Hanlon-Buchanan, Inc. Dale W. Moore will be vice president of the company but will continue to operate the Dale W. Moore Oil Company.

—Blank & Stoller.

DALE W. MOORE

For Scores of Refinery Uses



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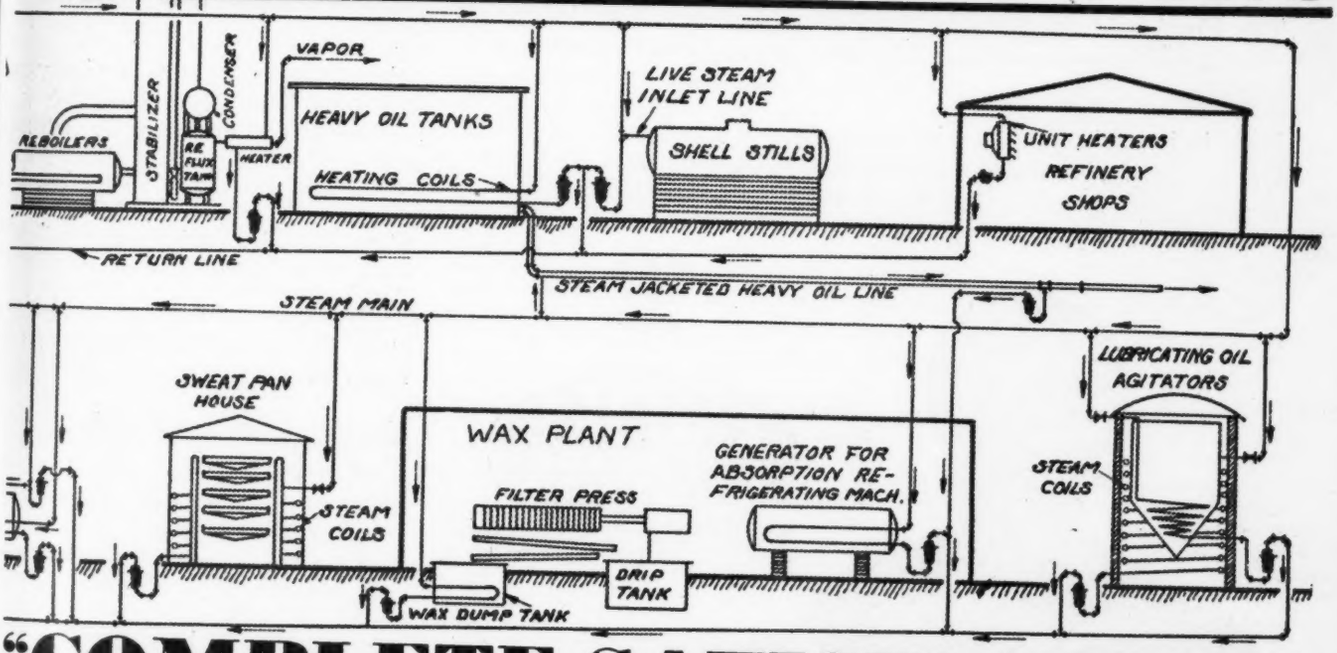

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Third Edition Petroleum Code Handbook Published

THE Petroleum Code Handbook for 1934, third edition, now ready for distribution, contains information of interest to all branches of the industry. It includes text of the recovery act, and supplements; the petroleum industry code—rules, regulations, interpretations, purchasing agreement, marketing agreements, supplemental marketing agreement, and the Pacific Coast cartel. The handbook also contains sections on the court actions under the code, enforcement of the code, price fixing, labor provisions, a record of the conservation movement, production and refinery control orders and regulations, marketing and transportation orders and regulations, and a code directory section giving the personnel of federal and state executive and regulatory agencies, and all of the code committees—regional and state. In addition it contains a list of about 5000 jobbers and independent filling station chain owners.

The handbook also includes revised facts and figures of the petroleum industry, comprising world statistics, exports, crude oil and gasoline prices, gasoline and motor vehicle taxes, crude oil production, wells, natural gasoline, government oil lands, refineries and refining, products of refining, oil pipe line statistics, tank cars, railroad transportation, motor vehicles registered and produced, aeronautics, and oil heating.

Purchasers of the handbook will receive without extra charge (12 monthly supplements keeping code information up to date. The Petroleum Code Handbook can be secured through the Book Department, Gulf Publishing Company, Houston, Texas, price $10.00.

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Chemical Engineers Visit at Bayonne

THE American Institute of Chemical Engineers were the guests of Standard Oil Company of New Jersey on a tour of that company's refineries at Bayonne and its extensive laboratories at Bayway, New Jersey, during a recent three-day meeting of the Institute.

The members sailed down New York bay from West 35th Street, left the steamer at Bayonne, went through the refineries and were then taken by bus to Bayway where they visited and inspected the company's laboratories, witnessing the technique employed there in modern research in petroleum chemistry.

They returned to New York that night and resumed their meeting the next day.

Cracked Gasses Used For Graf Fuel

DUBBS cracked gases, and not gasoline or benzol, are the fuels now used for the engines of the giant airship, Graf Zeppelin, according to dispatches from Germany.

The Graf is in passenger and mail service, flying on a regular schedule between Friedrichshafen, Germany, and Pernambuco, Brazil.

The gas used is a mixture of propane and butane, with sufficient hydrogen added to give it the proper density.

The propane-butane gas is a by-product of the stabilization of cracked gasoline from the Dubbs cracking unit in the plant of the Deutsche Erdoel Raffinerie at Misburg, near Hamburg.

The gas is bottled at the refinery in steel containers and shipped to the terminals at Friedrichshafen and Pernambuco.

American Petroleum Industry's Exhibit Again Feature of Fair

ON May 26, the 1934 edition of A Century of Progress Exposition opened its gates. It is by no means the same World's Fair. In every way it has been added to, replanned and reconstructed, profiting by the experience of last year. The exhibit of the American Petroleum Industries covering 6000 square feet in the Hall of Science, has been retained. This feature, one of the most outstanding in the Science building, has likewise undergone complete overhauling and refurnishing. So popular and so instructive was it acclaimed last year, that no basic changes have been made.

In keeping with the dramatic presentation of scientific discoveries which typified many exhibits last year, the petroleum exhibit was of unusual interest and the occasion for curious study by the great crowds that came to the Hall of Science. By official count, this building was among the most popular attractions at the Fair, and the Petroleum Industry Exhibit with conspicuous and centrally located displays, was viewed by a large percentage of these visitors.

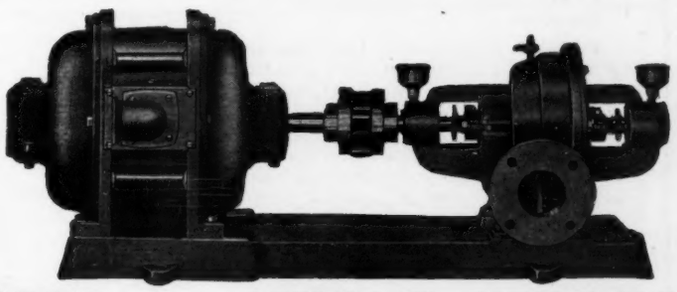
Its primary function was to inform the public, to show motorists and operators of plants and factories with what care, what ingenuity, and with how many modern scientific means crude oil is brought from the ground and, through all the phases of the industry, finally served to the consumer. Not only did the various dioramas, models, transparent photographs, graphs, captions and synchronized voice lectures show the work entailed, as well as the many mechanical elements incorporating every branch of modern science, but also gave a clear indication of the thoroughness with which the oil men do their jobs, and brought some inkling of the enormous task and great expense of operating one of the nation's largest and most necessary industries.

A full range of oil operations covers every phase of the industry in the models, drawings and dioramas: 1. Geological —aerial, exploration and mapping; 2. Geophysical surveying; 3. Deep drilling, sub-surface geology; 4. Production; 5. Transportation and storage; 6. Refining.

The first exhibit, which serves as an introduction, acquaints the public with a modern oil field under ideal conditions. Derricks are lined up along property lines. Every piece of equipment used in the field is shown in miniature. The topography shows slight offsets suggesting a fault. Below the field, the "earth" has been cut away, and water, oil and gas are shown being drilled. All this is animated—the flow of the fluids and gas is through glass rods. Taken from the east side of the Coalinga oil field in California, this diorama has been modified to give a perfect expression of oil geological principles.

The use of dioramas last year brought a clearer understanding of all the processes. An actual foreground, composed of models in scale graduates into a painted background. Several of these are used, one being 18 feet wide by 12 feet high. Subterfuge to gain true effects is the paradoxical principle employed throughout the exhibits. Oil and gasoline, for example, are really colored water, and 79 motors, 49 pumps, seven air compressors, four sound mechanisms, four synchronized lighting devices and two scenic projectors are used to work the models and make their functions realistic.

Various other oil fields are also to be



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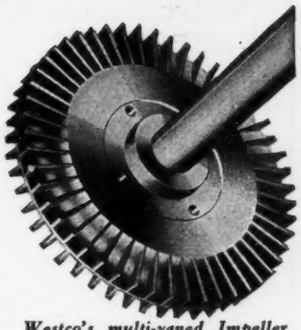

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DURING its travel from suction to discharge, liquid is recirculated a great many times through the hundred or more vanes on Westco's Impeller. Each vane imparts its proportional share of energy to the liquid. This re-energizing action enables Westco to operate against high pressures in single-stage construction that would require multi-stage construction in the conventional type centrifugal pump.

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CHEMISTRY AND TECHNOLOGY OF CRACKING—*A. N. Sachanen and M. D. Tilicheyev.*

Published in December, 1932, this book is a valuable addition to the library of those interested in cracking unit design, construction, or operation, or in the general subject of the chemistry or cracking. This late work covers thoroughly the fundamental features of cracking, chemistry of cracking, chemical composition of cracked products, properties and chemical treatment, the principle cracking systems, and includes an excellent chapter on the hydrogenation of petroleum products.

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HANDBOOK OF PETROLEUM ASPHALT AND NATURAL GAS, Revised Edition Bulletin 25, Kansas City Testing Laboratory—*Dr. Roy Cross.*

This well known handbook was revised in 1931 and increased to 865 pages. Material incorporated in the first edition of Bulletin 25 was brought down to date. The following is included: Economics of Gasoline, Transportation Storage and Gaging, Properties of Crude Petroleum, Refining and Cracking of Petroleum, Properties of Refining Petroleum, Fuel Oil, Oil Shale, Asphalt, Natural Gas, Methods of Analysis, Tables, Patents and Publications. Well illustrated by graphs, charts and photographs, and replete with valuable tabulations. ..

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shown, to illustrate unusual conditions. A diorama of a scene in Mexico will demonstrate oil seepage, the gas bubbling to the surface through a pool of water. The Turner Valley field of Canada and an Oklahoma field representing two other kinds of geology are also illustrated.

After viewing these first presentations, the public is interested in learning how these oil fields are discovered, so the mysteries of geological surveying are next dsiplayed. Instruments used in surface geology are shown in actuality, and supplemented with views of surveyors at their work.

To illustrate aerial photography as a means of geological mapping, a diorama uses a small aeroplane which flies over a field. A projected beam from the plane lights up each area as it is photographed. A recorded voice explains the procedure. Below the field are actual aerial photographs.

Sub-surface geology is represented by models of the common geological strata, showing the embedding of oil in the earth. An asymmetrical anticline, a symmetrical anticline, as well as a salt dome are constructed in varied colors so that the different strata are plainly observable. Samples of cores and cuttings from drillings all over the country give the layman an accurate idea of how earth specimens are examined for oil content.

Geophysical instruments used in oil field exploration are subjects for many graphs, photographs, models and transparencies—colored photographs on glass, with light behind them. This highly technical side of oil prospecting, which has combined the work of the laboratory scientist with that of the scout, well demonstrates how the petroleum industry has taken advantage of the strides in modern science.

Drilling for oil wells is associated in the public mind with wildcats, with unexpected gushers, and with a good deal of luck. Sub-surface exploration replaces this old romantic notion with a newer mystery having fully as many thrills and all the intricacies of present-day discovery. One exhibit is devoted to the mapping of oil structures by explosion waves, explaining the seismic reflection and refraction methods. The torsion balance, used principally in the search for salt domes, is also the subject of an interesting display.

Next the visitor is initiated into the devious methods of drilling for oil and gas. Full size tools and equipment are placed before large models which show both actual drilling operations and the use of various tools.

It is pointed out, for example, that the Diamond drill is used to reach depths of 6000 feet or less. Hydraulic feeds, larger bits, cable tool rigs and derricks, "miniatures" standing 13 feet high, are animated, and continually working. The problem of fishing for tools is explained; a model of an exceptionally crooked hole displays how it is surveyed, the instruments which are used, and the causes of crooked holes. Models and charts illustrate the cementing of casings.

Pumping

In a large glass-enclosed case, which allows the observer to see the subsurface, is a model of a central power pumping unit. Four wells are connected, and through glass casings the oil is seen rising from the "pay" sand.

The recent adoption of water flooding of sands to increase the yield of depleted fields is the subject of an interesting exhibit that shows the methods used in keeping with the conservation of this great natural resource. The model is constructed from the project at Bradford, Pennsylvania.

Model Refinery

One of the most interesting exhibits of the industry is centrally located in the main room of the Hall of Science. Major refining operations, from the fractional distillation of crude oil to the final treatment of the five basic products, and in-

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cluding the cracking process, are demonstrated in a glass-enclosed model refinery, which extends 30 feet in length.

Towers, stills, tanks and pipe connections are cut away, and covered with glass, so that a trip around this small refinery discloses all the actions of modern methods. The separation and collection of crude oil vapors of different weights is vividly explained by bubbling liquids within the transparent tower. Another section demonstrates the treatment, chilling, and dewaxing of lubricating oils, as well as the final stages, in the asphalt and coking stills.

Transportation

Because distribution is one of the major problems of any industry today, and particularly because of the extremely complex combination of pipe line, water and rail transportation in the petroleum industry, a large model shows a terminal which combines all these facilities. A group of translites nearby traces the development from the early days of horse-drawn tank wagons and tankers which were then sailing vessels, to the modern transport methods of today. Illuminated maps complete the exhibit, giving the visitor a comprehensive idea of world gas and oil fields, and their relation to markets, through the medium of transportation.

Gasoline Plant: Construction has been started on a natural gasoline plant for Lomita Gasoline Company in the Mountain View field, Kern County, California. It should be in operation in July. It will have capacity for 10,000,000 cubic feet of gas. J. A. Campbell, chief engineer for the company, is in charge of construction.

Gasoline Plant: Gas & Oil Products, Ltd. is building an absorption plant in the South Turner Valley Field in Canada. Part of the equipment came out of Texas.

Booster Station: United Gas Company is building a booster station near Woodlawn, Louisiana, eight miles north of the Iowa field where Shell Petroleum Corporation is building a natural gasoline plant.

Dismantle: Canyon Refining Company, Kilgore, Texas, owner of a 1000-barrel crude skimming plant in the Kilgore section of the East Texas oil field, was forced to dismantle its equipment in May because of inability to renew lease on plant site.

Cracking Unit: Arrow Refining & Producing Company, Overton, Texas, began making trial runs late in May on its 1000-barrel crude cracking unit erected to operate in conjunction with its 5000-barrel skimming plant in the East Texas oil field.

Cracking Unit: Trinity Refining Company, Gladewater, Texas, has started construction work on a 1000-barrel capacity crude cracking unit to improve the efficiency of the company's 2000-barrel crude skimming plant located in the Gladewater section of the East Texas oil field. The skimming equipment was leased early last month to V. E. Jackson, Tom Sowell and others, who are operating same as Lone Star Refining Company.

Operating: The Osage Refining Company started operations in its remodeled plant at Osage, Wyoming, June 1. The plant was recently purchased from the Egaso Operating Company by E. C. Winters and associates of Kansas City. Winters formerly was connected with White Eagle Oil Refining Company. The plant will have a charging capacity of 1500 barrels and will operate chiefly on Osage crude.

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New Equipment for the Modern Plant

Steam Traps

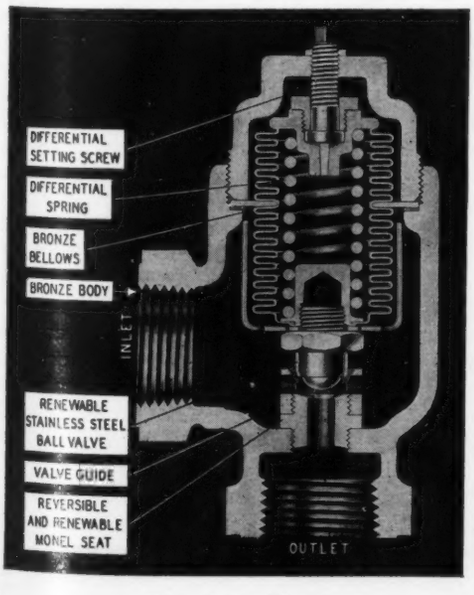
C. J. TAGLIABUE MANUFACTURING COMPANY

C. J. Tagliabue Manufacturing Company of Brooklyn, New York, has recently brought out a new thermostatic steam trap for industrial use. These traps are now offered in ½-, ¾- and one-inch sizes with greater capacity and far greater steam economy. By virture of unique principles applied to design and construction, they will do the work of larger and more costly traps, according to the maker.

The exclusive TAG differential setting feature, which was successful on the company's original trap, has been retained and continues to assure actual saving of steam. An adjusting screw located at the top of the trap may be set to discharge condensate at a temperature corresponding to as much as 20 pounds less than the operating steam pressure, whether it is 50, 75 or 125 pounds, without any further adjustment.

Other outstanding advantages are the renewable and reversible double life monel seat, and a renewable stainless steel ball valve, the ball of which is true to within 0.00005 of an inch. As a further protection the renewable valve guide holds the ball valve central to the seat and thus insures tight closing.

The company has just issued a bulletin illustrating and describing the many features of these new traps.

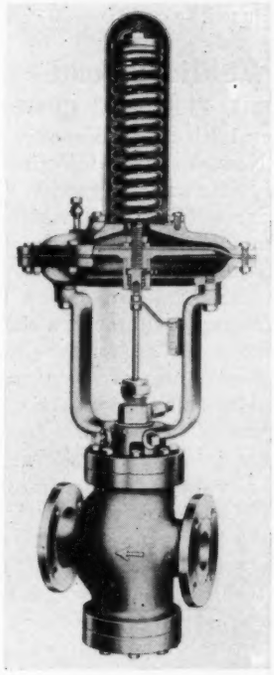


Tag Steam Trap

Valve

THE FOXBORO COMPANY

The Foxboro Company, Foxboro, Massachusetts, has announced the Foxboro Stabilflo Valve, a recent development in controlled valve design. It has several revolutionary features, according to the manufacturer.



Foxboro Valve

In the valve, Foxboro has upset tradition by reversing the usual position of diaphragm and spring. The result is a valve that gives an exact response to the slightest change demanded by the control instrument. The suspended construction of the diaphragm motor insures smooth valve action. The motor requires no guides. A special flexible coupling between the diaphragm motor and the valve stem permits the stem to establish its normal alignment.

Smoothness is enhanced further by a valve stem lubricator which reduces stuffing-box friction to a minimum. The lubricant protects and lubricates the packing and prevents leakage. To assure control throughout the entire range of the valve, the motor has been designed with a power factor ample to give true control results equal to the theoretical valve characteristics. The new valve port construction gives a flow rangeability of 50 to 1, or five times as much as present control valves. This means that the valve has equal percentage flow characteristics between 2 and 100 percent valve capacity, thus insuring satisfactory control for all demand conditions.

The valve and motor are ruggedly constructed. The open throat of the yoke permits air to circulate freely and protects the diaphragm against excessive temperatures. The Chrom-Vanadium steel spring is enclosed in an airtight pressed steel chamber which protects it from corrosive action. Each valve is equipped with a position index that shows the position of the valve plunger, and also shows at a glance whether the valve is an air-opening or air-closing type.

Valve

MYERS ENGINEERING EQUIPMENT COMPANY

Myers Engineering Equipment Company, 401 So. 12th Street, St. Louis, Missouri, has announced the Hoppe Electro-Hydraulic and Electro-Magnetic valves. These valves are made either of steel bronze or a non-magnetic body. Attached to the valve is a housing for a solenoid or magnet.

When the magnet is energized, it rolls the ball horizontally from the valve seat and retains it against the wall as long as the electric current is on. This releases the pressure which was surrounding the ball and permits the prompt passage of the element through the valve to its destination. When the current is turned off, the ball gently rolls back on the seat, thus closing the line tightly.

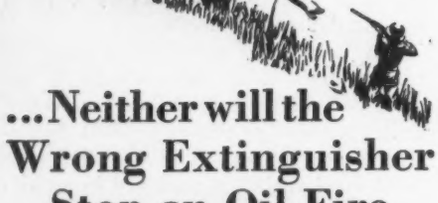
The simplicity of this electro-magnetic device with the ball as the only moving part, should eliminate a considerable amount of trouble since all packing is discarded entirely and, therefore, no leaks or sticking can occur, according to the manufacturer.

In both the electro-hydraulic and electro-magnetic valves, perfect balls are used and in most instances are made of stainless steel. Either valve can be buried underground or submerged in water and can be placed near explosive liquids or gases without injury since there is no exposed electrical arcing or sparking. Another feature is that no adjustments are necessary for these units once they are installed.

In St. Louis, these valves are now being used on ammonia, brine, compressed air, water and tests are now being conducted by a large refrigera-

A Shot Gun Won't Stop an Elephant

...Neither will the Wrong Extinguisher Stop an Oil Fire



HERE IS AN EXTINGUISHER THAT PUTS OUT THREE DIFFERENT KINDS OF OIL FIRES—NOT JUST ONE

BRIEFLY here are the facts; LUX extinguishers put out oil or gasoline fires burning on the ground as quickly as any other hand extinguisher. They put out fires in gasoline streaming through the air from a leaking pipe or overflowing tank truck against which other extinguishers fail. They also put out fires in live electrical equipment safely. No other type of extinguisher is effective against all of these fires.

You can't predict what your next fire will be. You know that the wrong extinguisher will be useless. Why not investigate LUX which will give you protection against all three?

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LUX

Triple Fire Protection for Refineries—Bulk Plants—Trucks

tion manufacturer on F-12 and methyl chloride.

The electro-magnetic valve can be used under similar conditions as the electro-hydraulic, except that its field at the present time is limited to the ¼-inch size.

It is felt that this electro-magnetic valve meets a need for a small electrically operated unit for the remote control of oil, gas, air, refrigerant and water lines. One of the popular uses to which it has been put is on air conditioning units where control of humidity is desired in the home. In this particular instance, a normal ¾-inch line is used.

Arc-Welding Head

GENERAL ELECTRIC COMPANY

General Electric Company, Schenectady, New York, is offering an improved automatic Type WFA automatic arc-welding head, which has several outstanding features, according to the manufacturer.

One small motor drives the electrode feed rollers through a simple worm reduction gear and three-speed transmission. At any of the three speeds, selected to suit electrode size, current, and rate of deposition of metal, the electrode is fed at a uniform rate and the arc voltage is accurately maintained. One small rheostat is the only adjusting element necessary. This means accurate control of the electrode feed, as all other operations are automatic.

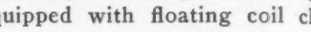
Handwheels swing the nozzle through complete circles in two planes at right angles to each other, thus permitting universal motion of the head. This feature provides a simple and accurate means for positioning the electrode with respect to the work or for following an irregular outline as the weld progresses.

The welding head complete consists of an insulated mounting support, an end plate which can be rotated and to which is attached an aluminum-alloy gear case containing the speed-reduction and transmission gears operating entirely submerged in grease. The motor is mounted vertically on the top of the gear case and is of the totally enclosed, ball-bearing type. It has adequate power, not only to feed the electrode but to straighten it as it comes off the reel. A circular aluminum-alloy plate carrying nozzle, wire guide, feed rollers, and feed-roller-pressure-adjusting knob is mounted on the left side of the gear case and can be rotated by means of a handwheel through a worm and worm wheel. A gear-shifting dial on the right side of the case permits ready selection of the desired transmission ratio.

Recording Thermometer

MASON-NEILAN REGULATOR CO.

Mason-Neilan Regulator Company, 1190 Adams Street, Boston, Mass., announces a new recording thermometer. This recorder is furnished in an attractive square Duralumin case with chromium plated hinges and hasp. It is equipped with floating coil clamp,



Mason-Neilan Thermometer

which it is said increases its accuracy by eliminating friction and lost motion.

These instruments may be equipped with the distinctive new over-heat protector, a safety feature which definitely protects the thermal element if temperatures exceed the instrument range. It is claimed with this new protector, that excess temperatures of 500° F. over the maximum chart range will cause no damage.

Recorders with multiple pens for recording several different temperatures can be furnished if desired. All parts are standardized and are interchangeable with other Mason-Neilan temperature control instruments.

Steam Trap

NASON MANUFACTURING COMPANY

Nason Manufacturing Company, New York City, has developed the Nason Ideal Steam Trap to handle condensation in any plant using steam for heating or machinery operation. Float principle permits simple, rugged construction, the float being made of heavy seamless copper and tested to 500 pounds pressure. A strong leverage allows discharging condensation as fast as it enters traps.

The trap maintains a water level sufficient to thoroughly submerge the valve mechanism. Steam can not enter the valve, and it is not affected by pulsating measures, according to the manufacturer.

The valve seat is made of phosphor bronze and is renewable. The valve stem has two-bearing alignment. The valve stem is monel metal and is reversible and renewable.

Pump

SLUDGE PUMPING, INC.

Sludge Pumping, Inc., Pier 18, North River, New York City, is offering the ArmEng Annular Steam Jet Pump, which was designed to remove and reclaim oil sludge and emulsions.

The pump is portable and will operate on steam pressure as low as 65 pounds. Higher steam pressures increase the pumping rate, however. The equipment, besides the pump, includes a 1½-inch flexible steam hose, and four-inch flexible steel discharge hose.

The pump is 18 inches long, five inches in diameter, weighs 23 pounds, and has no moving parts. The suction intake is dipped into the sludge, which is sucked into the ArmEng sludge pump and forced through the open discharge hose into any receptacle.

The sludge, being subjected to contact with a terrific steam velocity, is broken up into its original oily condition, in which it pours out of the discharge hose.

The manufacturer claims the pump will readily move sludge of a tarry coke nature, and will handle the heavier sludges which were formerly removed with shovels and wheelbarrows.

Electrical Tubing

STEEL AND TUBES, INC.

Steel and Tubes, Inc., Cleveland, Ohio, announces "Electrunite Steeltubes" electrical metallic tubing, a new type of conduit that provides a ball bearing surface that greatly reduces wire pulling friction.

Eagle-Picher Sale Company (Insulation Division) has opened a sales office at 312 Thompson Building, Tulsa, Oklahoma, with Marvin A. Smith, district sales manager in charge.

Arthur G. McKee & Company, engineers and contractors, Cleveland, Ohio, announce the receipt of its second contract since January 1, for United Refining Company's plant at Warren, Pennsylvania. It consists of a 2000-barrel re-run unit which will be placed in operation by September 1. The first contract, which consisted of a 2500-barrel crude distillation unit, goes into operation on June 15.

Universal Oil Products Company, owner of the Dubbs cracking process, has moved its New York office to 50 West 50th Street.

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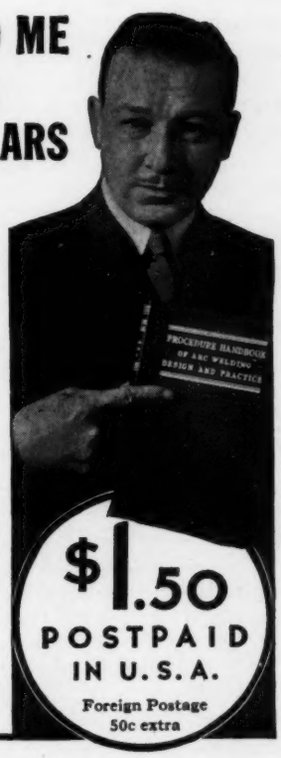

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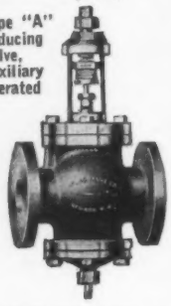

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Liquid Level Controllers

Fisher Governor Company, Marshalltown, Iowa, manufacturers of automatic control equipment, has announced the appointment, effective June 1, of Weeks Engineering Company, 4005 Gravois Avenue, St. Louis, Missouri, as factory representative for the St. Louis territory.

M. N. (Duck) Aitken, actively identified with the distribution of industrial process controls for Mason-Neilan Regulator Company in Chicago and Philadelphia during the past several years, has joined the staff of Maintenance Engineering Corporation, Houston, Texas, serving in a sales and engineering capacity.

W. W. Boyd of Tulsa, district manager of Combustion Engineering Company of New York, is leaving on an extended trip to Cuba and South America in the interest of company business. Boyd formerly resided in Havana, Cuba, and during his absence from Tulsa his office will be in charge of Geo. A. Widoe from Kansas City who is being transferred to Tulsa.

V. A. Cosler, well known rubber technologist, has become associated with the Rubber Division of E. I. du Pont de Nemours & Company, according to announcement recently made by the company. He will give a large part of his time to future distribution of products containing DuPrene, a synthetic rubber developed and now being made by the du Pont Company.

Cosler received his training as a chemical engineer at Ohio State University. He has been connected with mechanical goods manufacturers for over 16 years. He was with B. F. Goodrich Company for 13 years, and in 1930 joined the Hewitt Rubber Corporation as technical director. He is now a member of Committee D-11, Rubber Products, of the American Society for Testing Materials.

A. P. I. Has New Address

THE American Petroleum Institute has changed its New York headquarters to Room 2040 at 50 West 50th Street, according to notices sent out to the membership by Lacey Walker, secretary. For several years the Institute has maintained its general offices at 250 Park Avenue. The new location is convenient to railroad terminals and hotels. Members have been asked to cooperate with postal authorities, telephone and telegraph agencies to facilitate handling of mail and messages.

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